RAIB
Rail Accident Investigation Branch

Rail Accident Report

Collision between a train and a lorry and trailer on Llanboidy automatic half barrier level crossing
19 December 2011

Department for Transport

Report 20/2012
September 2012

This investigation was carried out in accordance with:

- the Railway Safety Directive 2004/49/EC;
- the Railways and Transport Safety Act 2003; and
- the Railways (Accident Investigation and Reporting) Regulations 2005.

Any enquiries about this publication should be sent to:

RAIB
The Wharf
Stores Road
Derby UK
DE21 4BA

Email: enquiries@raib.gov.uk
Telephone: 01332 253300
Fax: 01332 253301
Website: www.raib.gov.uk

This report is published by the Rail Accident Investigation Branch, Department for Transport.

Collision between a train and a lorry and trailer on Llanboidy automatic half barrier level crossing, 19 December 2011

Contents

This page is left intentionally blank

Summary

At 09:44 hrs on Monday 19 December 2011, a train running from Milford Haven to Manchester struck a lorry and trailer on Llanboidy automatic half barrier (AHB) level crossing, near Whitland in Wales.

The impact between the train and the lorry caused the lorry to be separated from its trailer and pushed along the track by the train. The lorry driver left his cab prior to the impact but was struck by the trailer and slightly injured during the collision.

The lorry had stopped on the crossing when the barriers lowered for the approaching train. The train driver saw the lorry when the train was 270 metres away and travelling at 68 mph (109 km/h). The train driver applied the emergency brake, but the train was unable to stop before reaching the crossing. The train was not derailed but 27 passengers were injured in the collision, one seriously, and four received treatment in hospital before being discharged later the same day. The train conductor and the catering host received minor injuries and were treated in hospital and the driver suffered shock.

The accident occurred because the lorry driver did not telephone the signaller for permission to cross and because local factors encouraged him to take a line towards the right of the road.

Road signs, in English and Welsh, on the approach to the crossing instructed drivers of large or slow vehicles to phone the signaller for permission to cross the railway. The road signs defined the terms ‘large’ and ‘slow’ and the lorry and trailer were of such a length, and were likely to have been travelling at such a speed, that the lorry fell within the scope of both of these terms.

A number of factors forced the lorry and trailer to use the right-hand side of the road to pass over the crossing; the orientation of the road over the crossing being misaligned with the rest of the road, the position of one of the road traffic light signals and the position of vehicles parked close to the crossing. While travelling slowly over the crossing the barrier on the exit side came down in front of the lorry, causing the lorry driver to stop his vehicle.

The RAIB has made six recommendations as follows:

- Network Rail in conjunction with the ORR to revise the crossing order and reduce the effect of road misalignment at the crossing;
- The ORR to revise its guidance to cover misalignment of the road and the ability for a large vehicle to exit an AHB crossing when the barriers descend;
- Network Rail to revise its risk management process for level crossings to include the effect of road misalignment;
- Network Rail to give guidance to its staff and contractors on where to park when working on or near level crossings;
- Angel Trains to examine how to mitigate the risk to the driver from detachment of cab panels during a collision; and
- Alstom and Angel Trains to review the coupler bump stop mounting and retention arrangements.

Introduction

1 The purpose of a Rail Accident Investigation Branch (RAIB) investigation is to improve railway safety by preventing future railway accidents or by mitigating their consequences.

2 The RAIB does not establish blame or liability, or carry out prosecutions.

The accident

3 At 09:44 hrs on Monday 19 December 2011, train 1W21, the 09:10 hrs passenger train service from Milford Haven to Manchester Piccadilly operated by Arriva Trains Wales, struck a lorry and trailer loaded with straw bales on Llanboidy automatic half barrier[1] (AHB) crossing, near Whitland in South Wales.

4 The impact between the train and the lorry caused the lorry to be separated from its trailer and pushed 78 metres along the track (figure 1). The lorry driver left his cab prior to the collision and was beside the trailer when the impact occurred. He was struck a glancing blow by the trailer and was slightly injured.

5 The train did not derail and the load bearing structure of the cab was not affected, but the glass reinforced plastic (GRP) skin was extensively damaged. The train driver left his cab before the collision, having applied the emergency brake and sounded the horn, and went back into the passenger saloon where he shouted a warning to the passengers. The driver suffered shock and the train conductor and train catering host both sustained minor injuries. There were 54 passengers on the train and 26 of them suffered minor injuries in the accident. One passenger sustained several cracked ribs. The injuries to passengers were caused by impact with tables and seat backs.

Figure 1: The train and lorry where they came to rest after the accident (most of the straw has been removed)

[1] An automatic half barrier crossing is equipped with barriers which close half of the road width on each approach to the crossing. The crossing sequence is activated automatically as a train approaches.

Background

Llanboidy AHB level crossing

6 Llanboidy AHB crossing is located between Whitland and Clunderwen stations, being approximately 0.75 miles (1.2 km) from the former and 4.6 miles (7.4 km) from the latter (figure 2). The railway is double track and is curved to the left in the direction of travel of the train involved in the accident. The maximum permitted speed for trains is 70 mph (112 km/h).

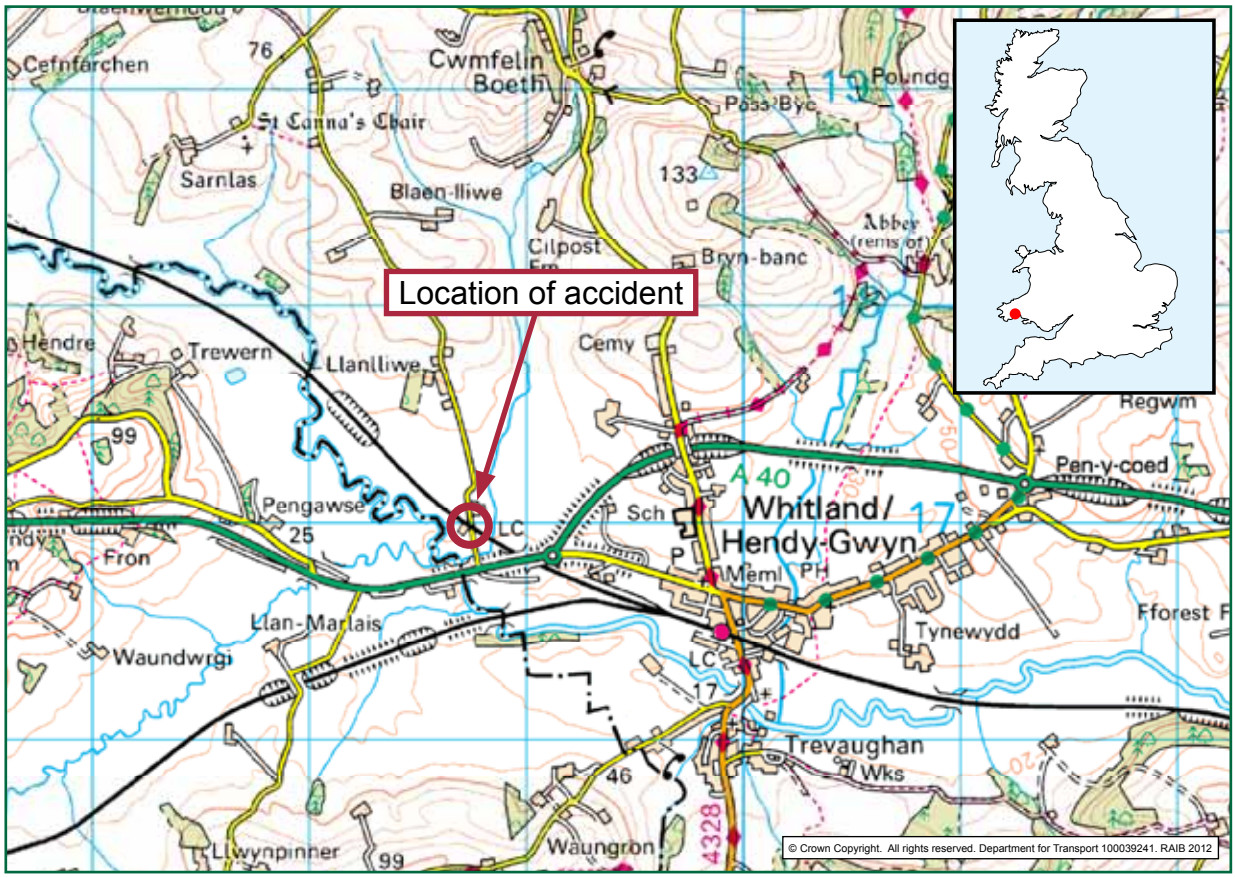

Figure 2: Extract from Ordnance Survey map showing location of accident

7 The line is signalled under the absolute block system[2] from Whitland signal box.

8 The crossing is equipped with warning signs in both English and Welsh, 'wig wag' road traffic light signals, half barriers and telephones which connect to Whitland signal box. Figure 3 shows the approach to the crossing in the direction that the lorry was travelling. The crossing is activated by approaching trains and indications of the status of the crossing equipment are displayed in Whitland signal box. The status indications show only whether the barriers have failed and whether the power supply to the crossing is on. These did not indicate a fault prior to the accident. The crossing was fitted with a data logger which showed that it was working correctly prior to the accident. Network Rail tested the crossing equipment, including the data logger, after the accident and no faults were found with the crossing, the datalogger or the crossing telephones.

[2] The system of signalling the railway where the safe operation of trains is achieved by allowing only one train at a time to occupy the section of track between two signal boxes.

9 The crossing was originally equipped with manually operated gates but was converted to an automatic open crossing remotely monitored (AOCR)[3] in 1985. In 1987, following an accident at an AOCR crossing on the Hull to Bridlington line where eight passengers were killed, a report was published[4], the Stott report, recommending the conversion of most AOCR crossings to AHB crossings. Llanboidy AOCR crossing was converted to an AHB crossing in 1992/3 and Her Majesty's Railway Inspectorate (HMRI) inspected and approved the AHB crossing arrangements in May 1993.

Figure 3: South approach to Llanboidy AHB crossing

The sequence of events

10 On the day of the accident, contractors working for Network Rail were installing cables at the track side between Llanboidy crossing and Clunderwen. They accessed the track at the level crossing and two of their vehicles were parked on the side of the road near the crossing on the north side (figure 4). There were another two vehicles parked on the left side of the road approximately 42 m from the crossing on the south side and a vehicle was parked in the field adjacent to the former crossing keeper's cottage.

11 The lorry driver worked for Meurig Davies Farm Seeds Ltd. He lived locally and was familiar with the road and the level crossing. He collected the lorry and trailer loaded with straw from a farm in Whitland where it had been parked since Saturday 17 December. This journey started at approximately 09:12 hrs. He drove to a nearby weighbridge, where the lorry and trailer were weighed, then set off for the farm where the straw was to be delivered. The final part of the journey to the farm was along a minor road which crosses the railway at Llanboidy AHB crossing.

[3] This type of crossing has flashing red lights to stop road traffic but no barriers. The correct operation of the lights is monitored remotely from the signal box.

[4] 'Automatic Open Level Crossings – A review of safety', Professor P F Stott CBE FEng, July 1987.

Figure 4: Road on the north side of Llanboidy AHB crossing showing parked vehicles (courtesy of BTP)

12 The lorry and trailer approached the crossing travelling very slowly and took a line across it such that, when it reached the exit (north) side, it was on the right-hand side of the road (paragraph 33). Just before the front of the lorry reached the half barrier on the exit side of the crossing, the barrier started to descend. The driver stopped his vehicle immediately and got out of the cab, believing that railway staff were working on the crossing and had caused the barrier to descend. The lorry was standing on the crossing obstructing both tracks at this time. The crossing was equipped with 'yodalarm' sounders to warn pedestrians and these were sounding at the time. They are activated by approaching trains as part of the level crossing operating sequence.

13 The train approached from the Clunderwen direction travelling at 68 mph (109 km/h). As the train rounded the curve and the crossing came into view, the driver saw the lorry on the crossing. He immediately applied the emergency brake and sounded the horn. He then left the cab, sounding the horn again as he left. The driver went back into the passenger saloon and shouted a warning to the passengers.

14 The train speed had reduced to 38 mph (61 km/h) by the time it reached the crossing and struck the lorry at 09:44 hrs. The impact broke the drawbar from the lorry trailer and the lorry was pushed by the train 78 metres along the line before coming to rest.

15 The front cab of the train was badly damaged so the driver made his way through the train to the back cab where he used the conductor's mobile phone to call the signaller. The signaller made the necessary arrangements to protect the line from other trains, called Network Rail operations control and called the emergency services.

16 The emergency services arrived at 10:06 hrs, 14 minutes after being called and within the target time of 20 minutes for rural areas[5]. The passengers were attended to by paramedics and taken off the train once road transport had arrived for them. Four passengers were taken to hospital for treatment to their injuries and were released later the same day.

Identification of the immediate cause[6]

17 **The lorry stopped on the crossing when the barriers descended for the passage of the train (paragraph 12).**

Identification of causal factors

The actions of the lorry driver

18 **The lorry driver did not telephone the signaller to get permission to cross the line, which he was required to do as indicated on the road signs on the approach to the crossing. Had he phoned, the signaller would have refused permission to cross because of the approaching train. This was a causal factor.**

19 The phones at the crossing connect to Whitland signal box and all calls are recorded. No calls were made from the crossing on 19 December prior to the accident. The lorry driver stated that he did not use the crossing phone and explained after the accident that he had not considered that his lorry and trailer needed permission to cross.

20 The road signs on the approach to the crossing are standard signs defined in the Traffic Signs Manual[7] and are the same as those provided at all AHBs in Great Britain (with the exception of the Welsh translation). They include one which states '*Drivers of LARGE or SLOW VEHICLES must phone and get permission to cross*'. Beneath the sign the terms 'large' and 'slow' are defined: '*LARGE means over 61'-6" (18.75m) long or 9'-6" (2.9m) wide or 44 tonnes total weight SLOW means 5 mph or less*' (figure 5). The length of the lorry was recorded in the Vehicle and Operator Services Agency (VOSA) vehicles database as 11.61 m and this dimension was broadly consistent with measurements made after the accident (the damage to the lorry made it impossible to measure its length accurately). The length of the trailer was recorded in the VOSA database as 9.81 m from coupling pin to the end of the trailer. However, the trailer was fitted with drop down flaps at the front and rear which extended its length and were in use at the time of the accident. The manufacturer's drawing of the trailer showed that it was 11.07 m long with the flaps extended. The combined length of lorry and trailer, when coupled together, was calculated as 21.48 m at the time of the accident. As this was longer than the length defined as 'large' on the sign (over 18.75 m), the driver should therefore have phoned for permission to cross the line.

[5] The target response time for Dyfed-Powys police to respond to 'grade 1 - immediate response' calls, from http://www.dyfed-powys.police.uk/en/about-us/performance/response-times.

[6] The condition, event or behaviour that directly resulted in the occurrence.

[7] The Traffic Signs Manual is published by the Department for Transport and is intended to give advice to traffic authorities and their agents on the correct use of signs and road markings. Mandatory requirements are set out in the Traffic Signs Regulations and General Directions 2002.

Figure 5: Sign reminding drivers of large or slow vehicles to call signaller

21 The 18.75 m dimension for the maximum length of a vehicle, above which it is necessary to phone for permission to cross, corresponds to the maximum length allowed for a lorry and trailer by the Road Vehicles (Construction and Use) Regulations 1986. Vehicles longer than this have to be specially authorised to travel. The lorry driver drove this lorry regularly and would have been aware that the vehicle and trailer combination was longer than 18.75 m as he had been stopped by VOSA officers while driving this lorry and trailer on 22 August 2010 and issued with a fixed penalty notice for driving a rigid vehicle and trailer over 18.75 m long.

22 The lorry was owned and operated by Meurig Davies Farm Seeds Ltd who had obtained it approximately two years before the accident. This lorry and trailer had been stopped by VOSA officers and its driver given a fixed penalty notice for driving a rigid vehicle and trailer over 18.75 m long on three other occasions between September 2010 and August 2011.

23 The lorry driver stated that the wig wag traffic signals at the crossing were not illuminated when he reached the crossing; this cannot be corroborated, but is consistent with analysis of the lorry's tachograph and the level crossing dimensions. The lorry's tachograph showed that the lorry was travelling slowly at the time. However, since there is a tolerance of +/- 6 km/h on the indicated speed it is not possible to use this data to derive the vehicle's exact speed as it drove onto the crossing.

24 The data logger at the crossing (paragraph 8) recorded that the wig wag lights were functioning correctly and the time between the amber road light illuminating and the barriers starting to descend was 8.5 sec. The RAIB has calculated that if the lorry passed the wig wag traffic signal at the moment that the amber light illuminated, the barrier on the far side (19 m away) would drop immediately in front of the lorry if its average speed was 2.24 m/s (5.0 mph) or less. The RAIB has therefore concluded that either the lorry's average speed over the crossing was 5 mph (8 km/h) or less, or the lorry passed the wig wag lights after they illuminated. Since the lorry driver thought that the barrier had descended due to railway workers working on the crossing equipment, it is likely that he did not see the lights illuminated when he passed them. It is concluded that the average speed of the lorry as it drove onto the crossing was at, or very close to, the speed at which a phone call to the signaller was necessary by reason of slow speed.

25 The lorry driver has stated that he understood that he only had to phone for permission to cross if he was driving a vehicle which was at risk of grounding. There is a road sign at the crossing which states '*DRIVERS OF LONG LOW VEHICLES phone before crossing*' (figure 6). The RAIB has been unable to establish why the driver had noted this sign but not the larger sign for large or slow vehicles. The tachograph shows that the maximum speed of the lorry over the last four minutes of its journey prior to arrival at the level crossing was 12 km/h.

Figure 6: Uneven road warning sign on approach to crossing

The layout of the crossing

26 **The road over the crossing did not align with the approaches on each side and the position of the nearside wig wag traffic light unit on the southern side increased the effect of this misalignment. The effect of this was to divert vehicles towards the right-hand side of the road when travelling north over the crossing. Network Rail had not recognised this misalignment as a risk factor at the crossing. This misalignment was a causal factor.**

27 The centreline of the road over the crossing was at an angle of 6 degrees to the left of the line of the road approaches. The effect of this misalignment was to make the half barriers jut out into the path of a vehicle taking a straight line over the crossing (figure 7). The misalignment first arose when the crossing was converted from manually controlled gates to an AOCR. The road over the crossing was widened to comply with the minimum width of 5 m for an AOCR crossing specified in the Department of Transport publication '*Railway Construction and Operation Requirements – Level Crossings'.* Physical constraints meant that the road was widened on opposite sides of the road on each side of the crossing (on each side of the crossing the road was widened on its right-hand side). This caused the widened road over the crossing not to be parallel with the rest of the road.

28 The Department of Transport Railway Inspectorate (RI) wrote to British Rail (BR - the infrastructure owner at the time) in April 1987 asking them to narrow the roadway over the crossing to 4 m and realign the edge markings as the road appeared skewed. This was done, though the date was not recorded. Figure 8 shows the crossing in November 1990 with the realigned edge markings.

29 Following the Stott Report in 1987 (paragraph 9), BR planned to convert all AOCRs to other types of crossing and wrote to the RI in April 1988 to propose that Llanboidy be converted to an AHB crossing. The minimum road width required by the Department of Transport at an AHB was 5 m and the RI told BR that they could not agree to a reduction below this value.

30 The road layout was altered and the crossing converted to an AHB crossing which was inspected and approved by HMRI[8] in May 1993.

31 There is an inherent risk with automatic crossings that road traffic might not be able to get clear of the line if the barriers start to descend while a vehicle is on the crossing. For this reason, AHB crossings have barriers which only close half of the road width, allowing a vehicle already on the crossing to move off after the barriers have started to descend. Road signs are provided warning drivers to keep the crossing clear (figure 9).

32 The Department of Transport requirements (paragraph 27) specified that the half barriers should leave a clear exit width of at least 3 m between the end of the barrier and the edge of the adjacent footway. The position of the barriers at Llanboidy met this requirement, though the footway was not marked on the ground at the barrier positions.

[8] The RI was transferred to the Health and Safety Executive in December 1990 and was thereafter known as Her Majesty's Railway Inspectorate (HMRI). Since 2006 it has been part of the ORR.

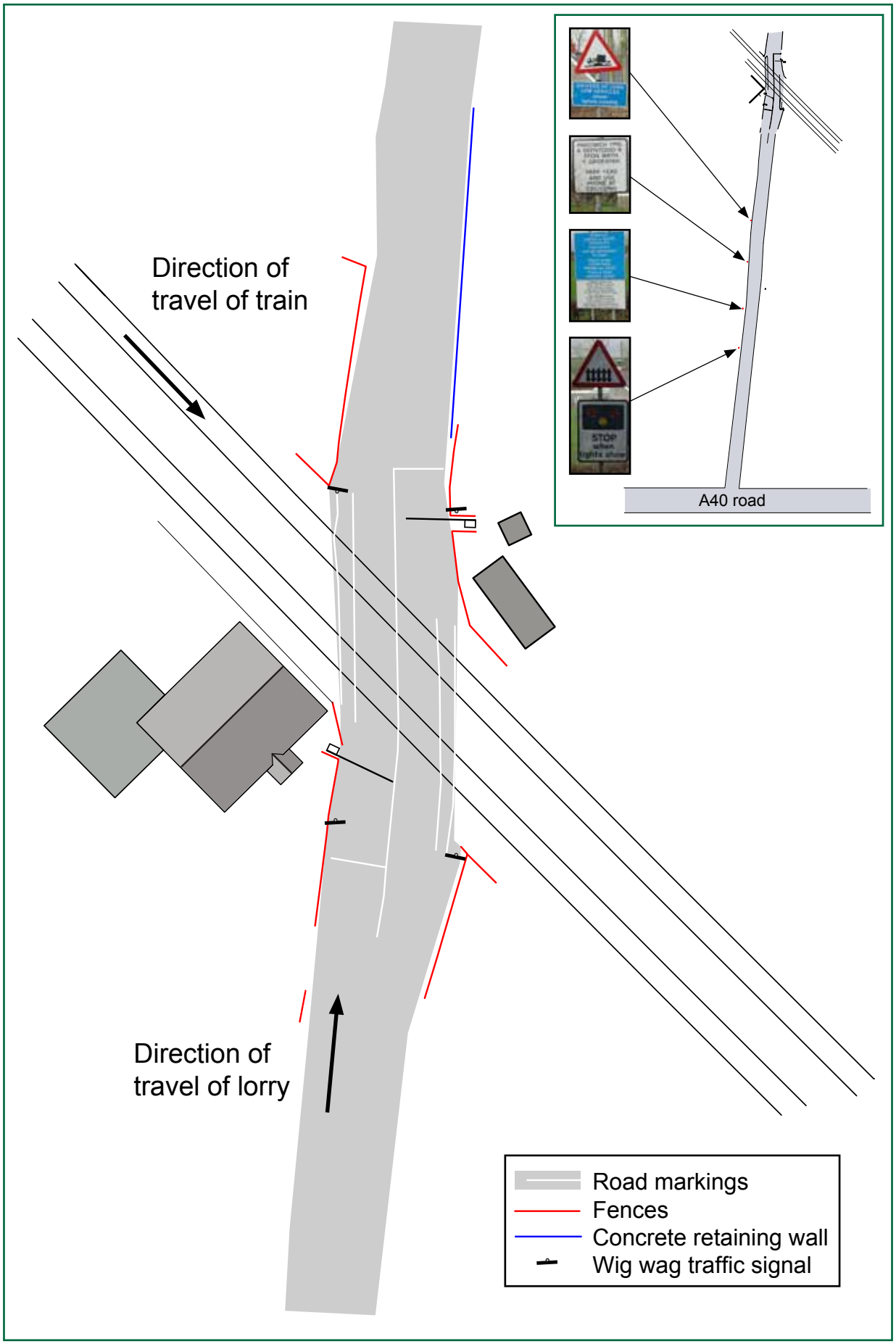

Figure 7: Plan of the crossing (to scale)

Figure 8: Llanboidy crossing as an AOCR in 1990 (photo courtesy of Network Rail)

Figure 9: Wig wag signals at the south side of the crossing

33 The RAIB commissioned a swept path analysis of the lorry and trailer passing over the crossing to determine whether it would have been possible for the lorry and trailer to have exited with the half barrier on the far side lowered. This analysis found that it would only have been possible to manoeuvre past the barrier if a line was taken to the left of the road centreline approaching the barrier on the far side. The clearances involved were so small that a driver would be unlikely to achieve this manoeuvre without assistance from someone on the ground. The analysis was repeated with the parked vehicles on the north side in place[9], in the position shown in figure 4, and it was found that, although the manoeuvre was still possible, the clearances were reduced still further. This was also the case when the analysis was repeated using a vehicle and trailer of maximum legal length. The position of the wig wag signal at the south side of the crossing forced vehicles to the right as they entered the crossing and the alignment of the road and good visibility beyond the crossing (paragraph 27) encouraged drivers to continue on the right-hand side of the road.

34 The position of the wig wag light signals was shown on the crossing ground plan dated 25 June 1993 associated with the level crossing order[10]. The position was also specified in the Department of Transport's *Railway Construction and Operation Requirements – Level Crossings*; the same requirement is included in the current ORR guidance document *Railway Safety Publication 7 'Level crossings: A guide for managers, designers and operators'*. The position is defined as the distance between the nearest red light lens and the edge of the carriageway. This distance is defined as not less than 810 mm and not more than 1500 mm, meaning that the light unit backboard is clear of the carriageway. The position of the nearside wig wag unit on the south side of Llanboidy crossing did not comply with this requirement. The light unit was positioned at the edge of the carriageway and projected out into the carriageway by 1072 mm, meaning that the red lamp was 700 mm into the road rather than a minimum of 810 mm back from it (figure 9).

35 The combined effect of the wig wag signal being positioned too far out into the carriageway, the misalignment of the road over the crossing with the rest of the road and the position of parked vehicles on the far side (paragraph 40) would have been to encourage a lorry driver to take a line towards the right-hand side of the road. This line was obstructed by the half barrier on the far side lowering for the passage of the train.

[9] The vehicles on the south side were not considered in the swept path analysis as, although the lorry would have moved to the right to pass them, the position of the trailer after the incident showed that the lorry had returned to the left side of the road before reaching the crossing.

[10] The level crossing order is a Legal Order made under the Level Crossings Act 1983 which specifies the particular arrangements at a level crossing.

36 Network Rail has several processes in place for periodic inspection, maintenance and risk assessment of AHB crossings:

- Maintenance staff carry out inspections every seven weeks following a process specified in Network Rail's standard NR/L2/SIG/19608 'Level Crossing Infrastructure: Inspection and Maintenance'.
- Signalling staff carry out inspection and maintenance according to Network Rail's standard NR/SP/SIG/10660 'Implementation of Signalling Maintenance Specifications', process RT/SMS/LC10 'Level Crossing Inspection and Maintenance'. This specifies two levels of inspection and maintenance, one to be done every three months and one annually.
- Operations staff carry out a risk assessment of the crossing every 18 months, which involves a site visit to gather data on crossing usage and other factors. These assessments are carried out to provide input to Network Rail's All Level Crossings Risk Model (ALCRM) (paragraph 38) and are mandated by Network Rail standard NR/SP/OPS/100 'Provision, Risk Assessment and Review of Level Crossings'.

37 Standard NR/L2/SIG/19608 clause 7.3.2 states that the annual maintenance and inspection specified by NR/L2/SIG/10660 is the means by which Network Rail check that the crossing remains compliant with the level crossing order and ground plan. The last annual maintenance and inspection visit prior to the accident was conducted on 15 October 2011 and no issues were reported with regard to the positioning of the wig wag lights or the road markings. The list of checks to be carried out at the annual service includes checking the alignment of the lights but not their position (this checks the positions that the red light beams are focussed on, but would not identify that a wig wag unit was in the wrong position). It should be noted that the position of the wig wag lights would have been non-compliant with the ground plan at the time of inspection and approval of the crossing by HMRI in 1993.

38 The last risk assessment prior to the accident was undertaken on 21 July 2010. The risk assessment was done using ALCRM, which is a computer application to assist the risk assessment of level crossings. It takes the features and usage of the crossing into account to calculate a risk score. This is made up of two parts, a collective risk and an individual risk. The collective risk is an estimate of the total risk generated by the crossing (including road users and the occupants of trains), whereas the individual risk is an estimate of the risk of death for a notional regular crossing user. The risk score from ALCRM is intended to support and inform an assessor in considering the risk mitigation options for the crossing.

39 The most recent assessment of Llanboidy crossing in July 2010 assessed the risk as E5. This represents a collective risk of 5 on a scale from 1 (highest risk) to 13 (lowest). The individual risk, E, is also in 5th place on a scale from A to M. These values represent a moderate level of risk and, as such, the expenditure on mitigation measures that Network Rail could justify was limited. However, the risk assessment process and associated guidance does not include a facility to consider misalignment of the crossing relative to the rest of the road, and this was not taken into account by the assessor. NR/SP/OPS/100 states that ALCRM should be supported by expert judgement or additional risk assessment processes where required; guidance on site visits includes local issues that should be recorded. However, this does not include misalignment. If the misalignment had been considered, it is likely that the crossing would have been assessed at a higher risk which may have justified improvements being made to it.

The parked vehicles

40 **The contractors working on the line side parked their vehicles close to the crossing, partly obstructing the road on the exit from the crossing.**

41 The road exit from the crossing at the north side narrows from 5 m at the crossing to 3.8 m, which is the width of the road on this side of the crossing. The narrowing of the road is all on the left-hand side, so that vehicles travelling northwards must move to the right-hand side as they leave the crossing. The position of the parked vans on the left forced vehicles to move to the right earlier than they would otherwise have done, bringing them closer to the half barrier on the exit side of the crossing (paragraph 33).

42 The contractors carried out a risk assessment of their activities prior to commencing work on site. This identified a risk to site personnel from impact with site vehicles. The mitigations included briefing staff on access routes, maintaining clear access and using designated parking areas. No risk to members of the public arising from parked vehicles was identified and no parking areas were designated at Llanboidy crossing.

43 Network Rail's instructions to their contractor included a list of site access points where the contractor could access the line. These were all at level crossings, including Llanboidy crossing. The instructions did not include guidance on where to park at the crossings.

44 The RSSB[11] level crossing risk management toolkit provides advice to the industry on level crossing risks and their mitigations. The parking of vehicles belonging to railway staff visiting the crossing close to the crossing is listed as a risk. Four mitigation measures are suggested; BTP monitoring of the crossing, joint action meetings between Network Rail and local authorities, double yellow lines on the road approaches and better notification of road works in the vicinity of level crossings. Briefing railway staff on where to park when visiting crossings is not mentioned.

[11] The company is registered as 'Rail Safety and Standards Board', but trades as 'RSSB'.

ORR Guidance on AHB crossings

45 The ORR publishes guidance on level crossings in Railway Safety Publication 7 *'Level crossings: A guide for managers, designers and operators'.* The guidance states that AHB crossings should have a minimum clear exit width of 3 m between the end of the barrier and the footway edge. The alignment of the road is not mentioned and there is no requirement to check whether a vehicle of the maximum size permitted can actually manoeuvre through this gap (paragraphs 32 and 33).

46 The difficulty in manoeuvring past the barrier on the north side of Llanboidy crossing arises from the alignment of the road on that side of the crossing. The ORR guide does not give guidance on the alignment of crossing approaches for an AHB crossing or how to deal with cases where the road and crossing do not align.

Severity of consequences

Crashworthiness of the train[12]

47 The train involved was a two-car class 175 diesel multiple unit manufactured by Alstom in 1999. The train was designed to comply with the structural requirements of Group Standard GM/RT2100 issue 2 – '*Structural requirements for railway vehicles'*. This version of the standard did not include requirements concerning the crashworthiness of the interior fittings (seats and tables).

48 The compliance of the train with Railway Group Standards was required to be checked by a Vehicle Acceptance Body (VAB) which issued an engineering acceptance certificate for the train to show that it met the requirements. Alstom used its own internal VAB to check the compliance of the first two class 175 units with standards. Correl Rail, which was formed from a management buyout of the Alstom internal VAB, did this for the remaining units. Correl Rail issued the engineering acceptance certificate for unit 175 002 on 24 October 2001 confirming compliance.

Interior crashworthiness

49 The deceleration in the train created by the collision with the lorry was within the design load case for the train. The passengers' injuries were generally minor and those that were sustained were mainly by impact with tables and seat backs. The seats and tables withstood the loads imposed by the impact without disproportionate damage.

50 The train interior was designed to meet the requirements of code of practice GM/RC2502 '*Code of Practice for Structural Aspects of Railway Vehicle Interiors*'. This specified that both the tables and seats should be capable of withstanding a set of static loads without permanent deformation. It did not include any specific requirements for crashworthiness performance in terms of injuries to occupants. Similarly, GM/RT2100 issue 2 was also silent on the performance of seats and tables in a collision. However, the current version of GM/RT2100 (issue 5) includes crashworthiness requirements for seats and tables.

[12] 'Crashworthiness' is a term used to describe the way in which a vehicle protects its occupants in a collision.

51 The Railways (Interoperability) Regulations 2011 mandate that all new trains should be designed in compliance with the Technical Specification for Interoperability (TSI). Where a particular area of the design is not covered by an existing TSI it is considered to be an 'open point' which must be addressed by compliance with standards notified to the EU by the member state (known as Notified National Technical Rules - NTRs). The most recent notification of UK NTRs took place in August 2012 and includes GM/RT2100 (issue 5). A new train designed today would have to comply with it. Interior crashworthiness is not covered by an existing TSI.

Exterior crashworthiness

52 The front end of the train includes a steel frame designed to withstand static strength and crashworthiness criteria specified in Group Standard GM/RT2100 Issue 2. These requirements ensure that the steel frame would not deform and would protect the occupants in minor collisions and that in a major collision, the front end of the train would be capable of absorbing up to 1 MJ of collision energy. Alstom decided to increase this requirement and designed the front end of the train to absorb 1.5 MJ of energy.

53 The outer surface of the front of the train comprised a glass reinforced plastic (GRP) skin attached to the steel structure. An inner GRP skin was also fitted which provided the interior surfaces of the cab. The gap between these skins was utilised to provide space for insulation and train equipment, such as wiring and cab instruments. The laminated windscreens were attached to the outer GRP skin. Neither the GRP skins, nor the interior equipment were considered by Alstom when assessing the performance of the front end of the train in a collision scenario. It was assumed that the GRP skins do not contribute to the static strength or the energy absorption capacity of the front end.

54 Alstom assessed the class 175 GRP skins against the requirements of Group Standard GM/TT0179 – '*Structural Requirements for Body-Mounted Equipment on Railway Vehicles'* and provided documentary evidence to its VAB to this effect. Alstom supplemented the loads from specified accelerations/decelerations prescribed in GM/TT0179 with aerodynamic loading. Collision loads between objects and the GRP were not specified in the standard and were not considered in the design.

55 Group Standard GM/TT0179 Issue 1, clause 3.1 requires that if failure occurs to body mounted equipment (eg GRP skin and the mountings) as a result of a collision, the possibility of injury to people shall be minimised both inside and outside the vehicle. Documentary records provided by Alstom indicate their intention was that these requirements would be met by compliance with the inertial loads from GM/TT0179 and appropriate selection of materials. The design approach adopted by Alstom was that the cab steel frame would absorb the energy required in the collision and the rest of the equipment including the GRP skins would remain fastened to the steel frame in the event of an accident.

56 In the collision, the steel structure remained undamaged as the collision forces were not high enough to deform it. However the GRP skins became detached from the steel structure as they were hit by the lorry's load which pushed the skins towards the inside of the cab. Parts of the inner GRP skin intruded into the area around the driver's seat and compromised his survival space. It is likely that he would have sustained injury, had he not left the cab before the collision (figure 10). It should be noted that GM/RT2100 Issue 5 and the TSI, by reference to European Standard EN15227 *'Railway Applications – crashworthiness requirements for railway vehicle bodies'*, now includes a specific definition of, and requirement for, a driver's survival space. This requires that deformation of the structure does not cause any vehicle equipment or parts to encroach into the designated survival space during the specified collision scenarios. RAIB calculations accounting for deformation of the obstacle showed that the collision scenario at Llanboidy was less severe than any of the EN 15227 scenarios for level crossing collision at a comparable speed.

Figure 10: Driver's seat showing position of GRP panels after collision

Coupler bump stop

57 The coupler at the front of the train is equipped with rubber and steel bump stops to limit its lateral travel. One of these bump stops became detached during the impact with the lorry and was found on the track near to the crossing. The bump stops are attached by means of bolts in slotted holes.

58 The RAIB noted in its report of the investigation into the derailment at Oubeck North, near Lancaster on 4 November 2005 (19/2006, published November 2006) that, in collision scenarios, the bump stops can become detached and fall to the track behind the train's obstacle deflector further increasing the risk of derailment. The investigation into the Oubeck derailment raised concern as to whether the load cases in GM/RT2100 included appropriate combinations of lateral, vertical and longitudinal loads experienced at the coupler head. In particular, whether the 'jack-knife' load case was correctly accounted for. The RAIB made a recommendation (No. 4) in the report into the derailment at Oubeck North to review GM/RT2100 in this respect. Notwithstanding the fact that the industry rejected the recommendation, the RAIB is still of the opinion that review of the standard would be beneficial.

59 The coupler bump stops are provided to limit the lateral movement of the coupler but are also required to detach under extreme loading to ensure that the coupler bar can retract beneath the vehicle body in a heavy collision, thus allowing the energy absorption structures at the front of the train to come into play. However, the current arrangement creates a risk of derailment if a bump stop (which weighs 16 kg) is ejected behind the train's obstacle deflector, something that could be avoided by secondary retention of the bump stops.

Other Incidents at Llanboidy crossing

60 A collision between a passenger train and a lorry occurred at the crossing on 27 July 2012. The train was also travelling from the Clunderwen direction towards Whitland. An empty flatbed lorry with a knuckle boom crane on the back was travelling from north to south over the crossing, the opposite direction to the lorry and trailer on 19 December 2011. The barrier at the north side of the crossing came down on the lorry between the cab and the knuckle boom crane. The lorry driver got out of his cab when he saw the train approaching. The train struck the lorry a glancing blow. Nobody was injured in the collision.

61 Network Rail tested the crossing after the incident and found that it was working as designed. The data logger showed that the lights and barriers had functioned correctly prior to the collision.

Summary of conclusions

Immediate cause

62 The lorry driver stopped his vehicle on the crossing when the barriers descended for the passage of the train (**paragraph 17**).

Causal factors

63 The collision between train 1W21 and the lorry occurred because:

a. the lorry driver did not phone the signaller to get permission for the lorry and trailer to cross the railway (**paragraph 18**); and

b. the lorry driver was encouraged to take a line towards the right of the road because;

i. the road over the crossing did not align with the rest of the road (**paragraph 26, Recommendations 1, 2 and 3**);

ii. the near side wig wag traffic light signal was wrongly positioned resulting in it being placed too far out into the road (**paragraph 26, Recommendation 1**); and

iii. the contractors working on the line nearby had parked two of their vehicles close to the crossing partly obstructing the exit (**paragraph 40, Recommendation 4**).

64 The following were also factors:

a. the Network Rail risk assessment procedure (ALCRM) does not include consideration of misalignment of the road and crossing (**paragraph 39, Recommendation 3**);

b. the ORR guidance on level crossings does not give advice on how to deal with cases where there is misalignment between the road and the crossing **(paragraph 46, Recommendation 2**); and

c. Network Rail did not brief their staff and contractors on where to park when visiting level crossings and the level crossing risk management toolkit did not include this as mitigation to the risk of crossing visitors parking nearby (**paragraph 44, Recommendation 4**).

Observations

65 The RAIB has observed that:

a. the risk of detachment of the GRP cab surround from the steel structure during a collision was not recognised during the certification of the class 175 train (**paragraph 56, Recommendation 5**); and

b. one of the coupler lateral bump stops became detached during the collision (**paragraph 59, Recommendation 6**).

Recommendations

66 The RAIB has made the following recommendations[13]:

1 *The purpose of this recommendation is to make the crossing, as viewed by a road user, more closely parallel to the rest of the road and hence provide a clear exit if the user is on the crossing when the barriers start to lower.*

Network Rail should develop an alternative arrangement for Llanboidy level crossing to reduce the apparent misalignment of the road over the crossing relative to the approaches and to bring the road markings and positioning of equipment including road traffic signals into compliance with current traffic signs regulations. Having developed a suitable design, Network Rail should propose to the ORR a revision of the Llanboidy level crossing order accordingly.

2 *The purpose of this recommendation is to give guidance on how to deal with crossings where site constraints force the road over the crossing to not be parallel with its approaches and to ask crossing designers to consider the escape route beyond the crossing rather than just the gap at the barrier line (chapter 2, paragraph 245 of the ORR guide).*

ORR should revise Railway Safety Publication 7 'Level crossings: A guide for managers, designers and operators' to provide:

- guidance on how to assess the misalignment between the centreline of the road over the crossing and the road approaches and how to mitigate its effects; and
- guidance supplementing the existing requirement for a 3 m minimum gap between barrier tip and road edge to ensure consideration of the actual vehicle exit path taking into account the largest vehicle permitted to use the crossing without telephoning the signaller.

continued

[13] Those identified in the recommendations, have a general and ongoing obligation to comply with health and safety legislation and need to take these recommendations into account in ensuring the safety of their employees and others.
Additionally, for the purposes of regulation 12(1) of the Railways (Accident Investigation and Reporting) Regulations 2005, these recommendations are addressed to the Office of Rail Regulation to enable it to carry out its duties under regulation 12(2) to:

(a) ensure that recommendations are duly considered and where appropriate acted upon; and

(b) report back to RAIB details of any implementation measures, or the reasons why no implementation measures are being taken.

Copies of both the regulations and the accompanying guidance notes (paragraphs 200 to 203) can be found on RAIB's website www.raib.gov.uk.

3 *The purpose of this recommendation is to ensure that the effect of misalignment of the road is taken account of in the Network Rail level crossing risk management process.*

Network Rail should revise its risk management process for level crossings to take account of risks arising from the misalignment of the road over the crossing relative to the rest of the road.

4 *The purpose of this recommendation is to prevent parked staff vehicles causing traffic to block back onto a level crossing, in particular vehicles of maximum legal dimensions.*

Network Rail should provide guidance to its staff and contractors on where to park their vehicles when working on or around level crossings where there is potential for such vehicles to block the access and egress from the crossing.

5 *The purpose of this recommendation is to find a means of mitigating the risk to the driver from detachment of the cab GRP structure during a collision.*

Angel Trains should investigate and, where appropriate implement, means of mitigating the risk to cab occupants from detachment of the cab GRP panels in class 175 units during a collision.

6 *The purpose of this recommendation is to reassess the risks associated with coupler bump stop mounting and retention arrangement.*

Alstom and Angel Trains should assess the safety risks of the existing design of the coupler lateral bump stop mounting. Where it is reasonably practicable to reduce the risk of a bump stop detaching and derailing the train, then these improvements should be implemented.

This report is published by the Rail Accident Investigation Branch,
Department for Transport.

Any enquiries about this publication should be sent to:

RAIB
The Wharf
Stores Road
Derby UK
DE21 4BA

Telephone: 01332 253300
Fax: 01332 253301
Email: enquiries@raib.gov.uk
Website: www.raib.gov.uk