RAIB

Rail Accident Investigation Branch

Rail Accident Report

Fatal accident at Halkirk level crossing, Caithness 29 September 2009

Department for Transport

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September 2010

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.

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Summary

On 29 September 2009 a collision occurred between a train and a car at the level crossing, at Halkirk, Caithness, resulting in fatal injuries to the three occupants of the car. There were no injuries to anybody on the train which was not derailed.

The most likely cause was that the car driver did not see and react to the flashing road traffic light signals because his eyesight was sub-standard.

An underlying factor was that Network Rail did not properly understand the risk at Halkirk level crossing because it had not taken the previous accident record into account. Had it done so, the level of risk might have justified more costly risk reduction measures, and risk reduction measures that had been identified might have been implemented more quickly and before the accident occurred.

The RAIB has made six recommendations to Network Rail which include the risk assessment of the level crossing and the maintenance of the backboards of the road traffic light signals.

Preface

1 The sole purpose of a Rail Accident Investigation Branch (RAIB) investigation is to prevent future accidents and incidents and improve railway safety.

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

Key Definitions

3 The report contains abbreviations and technical terms (shown in *italics* the first time they appear in the report). These are explained in appendices A and B.

The Accident

Summary of the accident

4 At 14:09 hrs on Tuesday 29 September 2009, the 10:38 hrs train from Inverness to Wick, reporting number 2H63, struck a medium sized hatchback car (a Nissan Almera) on the level crossing at Halkirk, Caithness (figure 1). The car was travelling in a northerly direction towards Halkirk village and the three occupants were fatally injured.

5 The level crossing is of the automatic open crossing, locally monitored type (AOCL), being protected by road traffic light signals but without barriers. Train drivers are required to monitor that the crossing is free of obstructions as they approach it.

Figure 1: Extract from Ordnance Survey map showing location of accident

6 There were no injuries to the 18 passengers on the train, or to the four train crew. The train, consisting of a two-car class 158 *diesel multiple unit*, was not derailed, but it did sustain minor damage as a result of the collision.

7 The RAIB is also carrying out a separate investigation to identify and assess safety issues associated with the operation of AOCL type level crossings, and to make recommendations with the aim of reducing the occurrence of accidents and incidents at AOCLs.

The parties involved

8 The three occupants of the car were all part of the same family. The car driver and his wife were both 81 years old and from Inverness. The third occupant of the car was the car driver's brother. He was 66 years old and from Latheron, Caithness. When the accident occurred, the car driver's wife was travelling in the back of the car, probably behind the front passenger seat, and the car driver's brother was in the front passenger seat.

9 First ScotRail was the operator of the train and the employer of the train crew (driver, trainee driver, conductor and catering trolley attendant).

10 Network Rail is the infrastructure manager and is responsible for the operation and maintenance of Halkirk level crossing.

11 Highland Council is responsible for the road crossed by the railway at Halkirk level crossing (except where it passes over the railway) and also for the signs provided in connection with, and on the approach to, the level crossing.

12 Northern Constabulary, the British Transport Police and the Office of Rail Regulation attended the scene of the accident. They, First Scotrail, Network Rail and Highland Council freely co-operated with the investigation.

Location

13 Halkirk level crossing is just south of Halkirk village, about 16 miles (25.6 km) from Wick and 7 miles (11.2 km) from Thurso, and is where the Inverness to Wick railway crosses Bridge Street, an unclassified road that gives access to the village (figure 2). The road runs approximately on a south to north orientation and is crossed by the railway 145 miles 59 chains from Inverness (the zero miles datum), between the stations at Scotscalder (143 miles 2 chains) and Georgemas Junction (147 miles 20 chains).

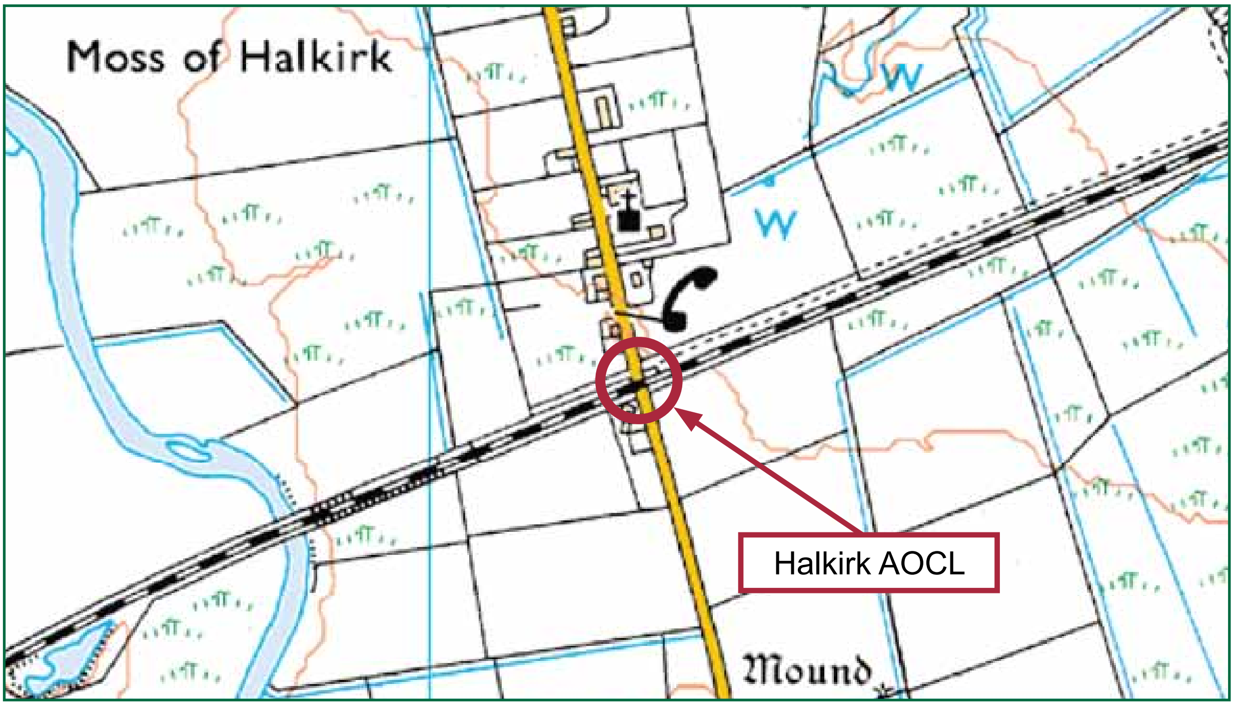

Figure 2: Map showing the layout of the road and the railway

14 The railway is single track and at the time of the accident the *crossing speed* was 50 mph (80 km/h) for passenger trains and 30 mph (48 km/h) for freight trains.

15 At the time of the accident, the railway was used daily by four passenger trains in each direction on weekdays and Saturdays, and by one passenger train in each direction on Sundays. Occasional freight traffic and special trains also used the line.

16 The road approaches the crossing from the south on a straight alignment and the speed limit for cars is 60 mph (96 km/h). There are 30 mph (48 km/h) signs 21 metres before the crossing stop line. This speed limit applies over the crossing and through Halkirk village.

External circumstances

17 The weather at the time of the accident was dry with sunshine and little wind. The visibility was good and the temperature was about 10ºC.

18 The elevation of the sun was 27.7º and was therefore reasonably low in the sky. It was shining from behind the car and onto the road traffic light signals on the south side of the crossing.

The level crossing

19 The level crossing at Halkirk (figure 3) was converted from an *open crossing* to an AOCL on 24 January 1971. A *level crossing order* that came into force on 25 September 1992, replacing an earlier order made in 1984, specified the protective equipment to be provided, such as the road traffic light signals, road markings and signage, and the duties on the railway operator concerning the maintenance and operation of the crossing. The arrangements at the crossing complied with the order at the time that the accident occurred.

Figure 3: Halkirk level crossing from the south

20 The crossing was designed in accordance with the Department of Transport's 'Railway Construction and Operation Requirements' covering level crossings[1]. This has since been superseded by the *Office of Rail Regulation's* (ORR's) 'Railway Safety Principles and Guidance, Part 2, Section E, Guidance on Level Crossings', published in 1996[2].

21 Halkirk crossing is protected by road traffic light signals, often referred to as wig-wags (figure 3), and, at the time of the accident, the light units[3] were fitted with 50 Watt halogen bulbs. The road traffic light signals are prescribed in the Traffic Signs Regulations and General Directions 2002[4] and are used to control road traffic at level crossings, swing or lifting bridges, tunnels, airfields or in the vicinity of premises used regularly by fire, police or ambulance vehicles. The backboards on which the light units are mounted have red and white chequered borders fitted to them to make them more conspicuous to approaching vehicles.

22 An audible warning is also provided at the crossing for pedestrian users. There are no barriers provided to close off the road when a train is approaching.

23 The level crossing order prescribes that when a train occupies a *track circuit* or operates a *treadle* the following sequence to close the crossing to road traffic should begin automatically:

- the amber lights shall show for approximately three seconds and the audible warning shall begin; and
- as soon as the amber lights are extinguished, the intermittent red lights shall show.

Not less than 27 seconds shall elapse between the amber lights first showing and the time when a train reaches the crossing.

24 Trains are required to approach the level crossing at the crossing speed, which commences at a speed restriction board provided in each direction. The order requires these boards to be approximately 494 metres from the crossing in each direction. This is the braking distance for trains at the crossing speed and the point at which train drivers can clearly see whether the crossing is clear or not.

25 Train drivers must monitor the operation of the crossing as they approach, to check that it is not obstructed. They must also check that a signal facing approaching trains, known as a driver's crossing indicator and located just before the crossing, has changed from an intermittent red light to an intermittent white light. The intermittent white light shows if at least one of the red lights of each road traffic light signal is flashing and the main power supply has not failed. If the intermittent white light does not show, the train driver must stop the train at the intermittent red light and not proceed over the crossing unless the train driver has made sure it is safe to do so (at some crossings there is an emergency plunger which the train driver can use to operate the crossing if there has been a failure of the equipment).

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[1] ISBN 0 11 550540 7.

[2] Railway Safety Principles and Guidance, Part 2 Section E, Guidance on Level Crossings, available from www.orr.gov.uk.

[3] A light unit consists of a housing, reflector, halogen bulb, coloured lens and a hood. Each road traffic light signal therefore consists of two red and one amber light units mounted on a matt black coloured backboard.

[4] Statutory Instrument 2002 No. 3113, ISBN 0 11 042942 7.

26 In each road direction, a sign is provided 106 metres from the road traffic light signals to warn of the level crossing ahead without gates or barriers. There is a second sign below it which depicts one of the road traffic light signals and the words 'STOP when lights show' (figure 4). Both signs are made more conspicuous by being mounted on a reflective yellow backboard. Guidance on the location of these signs is provided in the ORR's guidance on level crossings and in chapter 4 of the Traffic Signs Manual[5].

Figure 4: Signage on the approach to Halkirk level crossing

27 The Highway Code[6] states the following in respect of road traffic light signals at level crossings:

- you MUST always obey the flashing red stop lights;
- you MUST stop behind the white line across the road;
- keep going if you have already passed the white line and the amber light comes on; and
- at crossings where there are no barriers, a train is approaching when the lights show.

The Code also includes the diagram shown in figure 5.

[5] Department for Transport, fourth edition, ISBN 9780115524110.

[6] Department for Transport Driving Standards Agency the Official Highway Code 2007 Edition, ISBN 9780115528149.

Flashing red lights

Alternately flashing red lights mean YOU MUST STOP

At level crossings, lifting bridges, airfields, fire stations, etc.

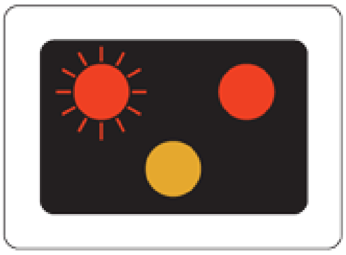

Figure 5: Signal details extracted from the Highway Code

Events preceding the accident

28 On 29 September 2009, the car driver drove from Inverness to Latheron, Caithness, with his wife, where they collected the car driver's brother to take him out for the day. The car driver was familiar with the Caithness area and would have driven over AOCL type crossings previously.

29 The occupants of the car were probably going to Scrabster, on the west side of Thurso, a routine that they generally followed once a month. The road at Halkirk level crossing gives direct access to the west side of Thurso, and this was probably the reason why they were travelling that way. Halkirk level crossing was therefore likely to have been familiar to the car driver, although it is not known how often previously he would have approached it when it was operating because a train was approaching.

30 The journey of the 10:38 hrs train service from Inverness had been uneventful and the train was running on time. The trainee driver, who was based at Inverness depot, was riding in the driving cab with the driver, also based at Inverness, who was at the controls.

Events during the accident

31 As the train approached Halkirk level crossing, the train driver reduced the train's speed in accordance with the speed restriction (paragraph 14) and saw that the intermittent white light was displayed indicating that the road traffic light signals were operating, and that the crossing was clear.

32 Just as the train reached the crossing, the car crossed from the train's right-hand side at an unknown speed and was hit by the train. The train's data recorder indicated that the train was travelling at 47.5 mph (76.4 km/h) at this point and the driver immediately applied the train's brakes, stopping 325 metres from the point of impact.

33 The train hit the rear of the car leaving vertical indentations caused by the train's gangway on the nearside rear passenger door and roof. The impact caused the car to rotate in an anti-clockwise direction when viewed from above and be pushed into steel picket fencing and the post supporting the road traffic light signals at the north-east corner of the crossing (figure 3).

34 A secondary impact with the train occurred as the train went past the car causing damage to the bodyside of the first coach 15.2 metres from the front of the train. This was almost certainly caused because the position of the car following the initial impact was constrained by the steel picket fencing.

35 A van approaching the crossing from the opposite direction saw the road traffic light signals flashing on the north side of the crossing and saw the train pass over it. The occupants of the van saw the car after the impact. One of them called the emergency services.

36 The train driver used the cab radio system to make an emergency call to the signaller at Inverness and to request that the emergency services be called.

Consequences of the accident

37 The three occupants of the car were fatally injured and the car was severely damaged on its nearside.

38 The train sustained minor damage to its front end, particularly the coupling. There was also some bodywork damage, the most serious of which was the hole in the left-hand side of the leading coach caused by the second impact with the car (figure 6).

39 Level crossing equipment on the north side of the crossing was damaged by the impact of the car.

Figure 6: The train involved in the collision at Halkirk level crossing

The Investigation

Investigation sources of evidence and process

40 Sources of evidence included:

a. an examination of Halkirk crossing, the car and the train involved in the accident;

b. the testing of the level crossing carried out the day after the accident;

c. witness statements;

d. train data recorder downloads;

e. meteorological reports;

f. Network Rail's level crossing file;

g. level crossing maintenance, inspection and risk assessment records and their associated standards and procedures;

h. the Northern Constabulary collision investigation report including the examination report on the car involved in the accident; and

i. reports of previous incidents and accidents at Halkirk crossing.

41 The RAIB commissioned specialist consultants to carry out an optical analysis of the south side road traffic light signals and to carry out a human factors study of the road approach to the crossing from the south. The optical analysis was undertaken to complement and reinforce the post accident testing and had three objectives:

- optical testing of the road traffic light signals to the applicable specification BR908: April 1991 'Light Unit for use in Level Crossing Road Traffic Light Signals' published by the British Railways Board;
- an investigation into the extent to which misalignment of the nearside road traffic light signals observed by the RAIB on site affected their *conspicuity* at different viewing distances; and
- an investigation into the degree to which sunlight falling on the road traffic light signals affected the conspicuity of the lit red light units, and to determine what difference long hoods would have made had they been fitted.

42 It was not possible to undertake the optical testing of the south side road traffic light signals in their original condition. In order to undertake this testing, it was therefore necessary to restore the signals as far as was possible to the condition they were in at the time of the accident (more details in paragraphs 71 and 72).

43 The RAIB also commissioned a consultant ophthalmologist to review the car driver's routine eyesight examination records with a view to establishing whether the car driver's eyesight could have been a factor in the accident.

Key Information

Site testing of the level crossing following the accident

44 Following the accident, Network Rail tested Halkirk level crossing in accordance with Network Rail's standard procedures. This site testing procedure was verified by and then observed by the RAIB's inspectors on site.

45 The site testing carried out included checks of the *relay* wiring and contacts; a *wire count*; *earth testing* of circuits; and testing of the track circuits and treadles that operate the crossing when a train approaches. The battery power at Halkirk was also confirmed to be sufficient to operate the crossing in the event of failure of the mains power supply. The alignment of the south side road traffic light signals was also checked.

46 The testing found no evidence of any defect that would have caused the level crossing not to have operated as it was designed to do.

The safety record of AOCLs

47 Key information concerning automatic level crossings can also be found in the RAIB's report on its investigation of the fatal accident at Wraysholme crossing, Flookburgh, Cumbria on 3 November 2008 (report no. 26/2009). For completeness, some of that information is repeated in this report. The history of AOCLs, including the response to the report by Professor P F Stott following the accident at Lockington on 26 July 1986, is in Appendix C.

48 Figures obtained by the Rail Safety and Standards Board (RSSB) from the European Rail Agency appear to show that level crossings in the United Kingdom have the best safety record compared with other European Community member states[7] (it is difficult to be certain about this because of differences in the way data is reported between countries). The risks of level crossings will be considered in more detail in the RAIB's class investigation of AOCLs.

49 At the end of 2009, of the 6592 level crossings of all types on Network Rail's managed infrastructure, there were 116 automatic open crossings, 23 (about 20% of the total) of which were in Scotland. These were all AOCLs apart from one *automatic open crossing, remotely monitored* (AOCR).

50 Between the beginning of 1998 and the accident at Halkirk on 29 September 2009, there were 62 collisions with trains at AOCLs on Network Rail's managed infrastructure. In three of the collisions, a total of four fatalities occurred, all to occupants of road vehicles. As a proportion of all types of level crossing, 31% of road vehicle collisions occur at AOCLs, with this type of crossing being 8% of the population of level crossings that are protected by lights, barriers or gates. Around a third of the collisions at AOCLs since 1998 have occurred in Scotland, including one that was fatal.

[7] Road-Rail Interface Special Topic Report, RSSB, www.rssb.co.uk/SiteCollectionDocuments/pdf/reports/road-rail_interface_str_full.pdf.

51 Although there are a relatively high number of vehicle collisions at AOCLs, the consequences are generally lower than at other types of crossings because of the associated limits on train speed (55 mph (88 km/h) is the maximum), and the fact that the train driver is required to check the crossing is clear before proceeding over it from a point where the train still has adequate distance in which to stop.

Vehicle driver behaviour at level crossings

52 In 1996, the Transport Research Laboratory carried out a study of the behaviour of vehicle drivers at level crossings[8] and identified three categories of vehicle drivers likely to be involved in accidents at level crossings:

- those who are unwilling to stop because they believe they have plenty of time to cross before the train arrives;
- those who are unable to stop because they are too close to the stop line at the onset of the amber or because someone is driving too close behind; and
- those who are unaware of the signals (i.e. the road traffic light signals) because they are inattentive or are distracted.

53 The research examined 419 witness statements that had been taken by the British Transport Police from vehicle drivers who had been seen to drive onto level crossings with the road traffic light signals operating. Just over a quarter of these drivers claimed to be unaware of either the crossing or the lights, but this figure should be treated with a degree of caution because some of the witnesses might have given this explanation to the police in order to lessen the seriousness of how the transgression was viewed. Over half of the drivers stated that they were unwilling to stop and had deliberately ignored the road traffic light signals. These figures were not differentiated by crossing type.

54 The proportion of vehicle drivers unaware of the road traffic light signals on the approach to AOCLs could be greater than at other types of crossing because there is no lowered barrier in the vehicle driver's forward field of vision. The report on the study mentions that since these drivers are not responding to visual signals, one method of proven effectiveness is the combination of auditory and tactile warnings provided by *rumble strips*. The possible use of rumble strips at Halkirk crossing is considered later in the report (paragraphs 113 to 119).

[8] Vehicle Driver Behaviour at Level Crossings, HSE Contract Research Report No. 98/1996, HSE Books, ISBN 0-7176-1093-4, www.hse.gov.uk/research/crr_pdf/1996/crr96098.pdf.

Previous occurrences of a similar character at Halkirk level crossing

55 Since 1998, the railway industry has logged accidents and incidents in its *Safety Management Information System* (SMIS). Incidents that occurred between 1990 and 1998 were imported into SMIS from a previous system. The RAIB was also advised during its investigation of another accident at Halkirk crossing in 1987. According to records, the following accidents and incidents have occurred at Halkirk level crossing since 1987:

- A fatal accident occurred on 27 June 1987 when a car driving out of Halkirk village ran into the side of a locomotive hauling a passenger train bound for Inverness. British Rail carried out an investigation, but the RAIB has been unable to obtain a copy of the report.
- On 12 November 1990, a train collided with a tractor and the tractor driver sustained minor injuries. The RAIB has not been able to find any other details.
- On 11 January 1993, there was another instance of a road vehicle being driven into the side of a train. There were no serious injuries and, according to the SMIS record, snow is believed to have been a factor. The RAIB has not been able to find any other details.
- A car was struck by the 07:21 hrs train from Inverness to Wick at 10:52 hrs on 18 October 2002. The car was travelling northwards towards Halkirk village. The single occupant of the car was seriously injured and there were no injuries to the passengers or crew on the train.

56 In the accident on 18 October 2002, the train was travelling at the correct speed of 50 mph (80 km/h) and no defects were found in the operation of the level crossing when it was tested after the accident. At the time of the accident, the sun was low in the sky and shining directly onto the road traffic light signals that faced the approaching car.

57 The Railtrack[9] investigation report concluded that the driver of the car failed to obey the road traffic light signals and that there was some evidence that sunlight might have been a factor in the actions of the car driver in failing to obey them. The report made seven recommendations. These and details of their subsequent implementation are presented in table 1.

58 There are several reports logged in SMIS of incidents where train drivers reported road vehicles driving over the railway when the road traffic light signals were operating. The most recent before the accident on 29 September 2009 occurred on 24 June 2005 when three cars were reported driving across the crossing when the road traffic light signals were operating. The level of reported incidents (‘near misses’) at Halkirk crossing is lower than at many other AOCLs.

[9] Railtrack was the predecessor organisation to Network Rail

Recommendation	Action taken
Railtrack shall encourage Highland Council to undertake to re-paint all white lines on the approaches to the crossing.	Implemented.
Railtrack shall encourage Highland Council to replace the road approach 771 and 773 signs[10] with the modern reflectorised equivalent.	Implemented.
Railtrack shall encourage Highland Council to apply a conspicuous anti-skid surface to the approaches of the crossing.	Not implemented.
Railtrack shall encourage Highland Council to erect *countdown markers* to the approaches of the crossing.	Not implemented.
Railtrack shall investigate the feasibility of upgrading the crossing installation to an automatic barrier crossing locally monitored type.	Completed and concluded that it would not be reasonably practicable to upgrade the crossing.
Railtrack shall arrange the installation of extended hoods over the road traffic light signals at the south side of the crossing.	References in correspondence obtained from Network Rail suggested this had been done, but given that standard hoods were fitted at the time of the accident on 29 September 2009, the RAIB concluded that this was not implemented.
First Engineering (a contractor to Railtrack) shall replace the audible warning control unit at the crossing.	Network Rail was unable to confirm whether this was implemented but it is not relevant to the accident.

Table 1: recommendations made following the accident at Halkirk on 18 October 2002

[10] The level crossing ahead warning sign and 'STOP when lights show' sign

Analysis

Identification of the immediate cause[11]

59 **The driver of the car did not react to the road traffic light signals and drove onto the level crossing at the same time as the train arrived.**

Identification of causal[12] factors

60 **The reason why the car drove onto the level crossing when the road traffic light signals were operating was likely to have been either:**

- **the car driver did not react to the flashing road traffic light signals because he did not see them; or**
- **the car driver did not understand the message given by the flashing road traffic light signals; or**
- **the car driver noticed the flashing road traffic light signals too late to be able to stop at them and therefore consciously decided to pass them.**

The RAIB considers that the first reason above is highly likely, as explained in the following paragraphs and is therefore a causal factor. However, the remaining two reasons are possible and cannot be totally discounted.

61 There are other possible explanations of why the car drove onto the level crossing (such as something causing a distraction in the car) which cannot entirely be ruled out but for which there was no evidence.

The car driver did not see and react to the flashing road traffic light signals

62 The most likely explanation of why the car driver did not see and react to the flashing road traffic light signals is because he had sub-standard eyesight.

63 Errors can occur when vehicle drivers fail to see the lights even if their eyes are directed towards them[13]. Drivers might not consciously see the lights, either because of other demands on their attention, or because they have no expectation of the lights being present. The car driver's sub-standard eyesight would have caused these effects to be more significant.

64 The poor condition of the backboards to the road traffic light signals, reducing the conspicuity of the lights, and the possible distraction caused by the 30 mph speed limit signs could also have increased the likelihood of the car driver failing to notice the lights.

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

[12] Any condition, event or behaviour that was necessary for the occurrence. Avoiding or eliminating any one of these factors would have prevented it happening.

[13] Marc Green, Inattentional blindness: let's not blame the victim just yet, Occupational Health & Safety Ja/F'02, 23-29, VOL.18, No.1. http://www.camc.ca/fr/SMS_40/Articles_270/8.html.

The car driver's eyesight

65 The expert's review of the car driver's eyesight records concluded that, on the balance of probabilities, the car driver's eyesight did not meet the standard set by the Driver Vehicle and Licensing Authority[14]. The evidence also indicated that he did not have distance spectacles to correct this so he would not have been able to see the road traffic light signals at the crossing as well as a person with vision that meets the standard.

66 The car driver had been advised to obtain distance spectacles at an eyesight examination in 2006, and then subsequently in 2009. The RAIB has concluded that he did not do so but has been unable to establish why not.

67 His impaired eyesight would have significantly affected the car driver's ability to determine a hazard such as a level crossing in front of him. He was also susceptible to glare (difficulty seeing in the presence of a bright light) and could have been affected in this way by the sunlight reflected from the backboards (paragraph 18).

68 The expert's view was that the car driver's impaired eyesight would have resulted in him being unable to read the signs warning of the approach to the level crossing until at a third of the distance that a person with vision that meets the required standard could read them.

69 The car driver's impaired eyesight would have dulled the effect of the flashing road traffic light signal; associated glare would have masked the flashing to some extent and the uncorrected optical error would have blurred the lights, effectively reducing the amount of light at the retina of the eye. It was not possible to determine the exact effects of each of these.

70 The expert's view was that the car driver, even with uncorrected defective eyesight, would have been more likely to have seen the crossing ahead if it had been fitted with half barriers, as the barriers would have been in his direct forward field of vision.

The conspicuity of the road traffic light signals - their brightness

71 The red light units used in the south side road traffic light signals were tested against specification BR908:1991 on *luminous intensity* (which was applicable at the time the lights were fitted[15]). The tests used red lenses that had previously been fitted to the north side light units owing to the absence of the original south side red lenses. These were determined to be in comparable condition to the missing south side red lenses by comparison with the amount of soiling, abrasion and weathering of the single remaining south side amber light lens.

72 It was not possible to determine whether the halogen bulbs supplied with the red light units were those that were fitted when the accident occurred and three of the bulbs appeared to be in new condition. The fourth bulb appeared to have been in service for some time and was initially used in the tests. However, after this failed due to corrosion, a bulb in new condition had to be used for the remaining tests. This should not have significantly affected the results of the tests because the decrease in light output of a halogen bulb is minimal during its life (up to 10%).

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[14] The Driver Vehicle and Licensing Authority's distance requirement for the eyesight test using old style car registration number plates is 20.5 metres or 20 metres if the new-style number plate is used. New-style number plates start with two letters eg AB 51 ABC.

[15] The current standard for road traffic light signals is BS EN 12368:2000 as defined in TR 2206:Issue A:2001, Specification for Road Traffic Signals published by the Highways Agency.

73 It was found that the south side red light units did not meet specification BR908:1991, but this specification applies to new light units whereas those in service suffer deteriorating light output over time due to the soiling, abrasion and weathering of the lenses, the ageing of the reflector and a slight reduction in bulb light output.

74 While recognising that modifications had been made to the red light units prior to the optical testing, the consultant concluded that the deterioration found against BR908:1991 relating to luminous intensity was reasonable given that the specification against which the testing was carried out related to new light units rather than those that had been in service for some time.

75 The tests also found that three of the four south side red light units tested with red lenses from the north side light units did not meet specification BS1376:1974 on colours for light signals, producing a deeper red colour than required. The optical consultant considered that the non-compliance with the red colour requirement was of the order expected for lights that had been in service.

The conspicuity of the road traffic light signals - the effect of sunlight

76 The matt black backboards and chequered surrounds (particularly the offside backboard) were faded and unable to prevent the reflection of sunlight (figure 7). The expert's view was that this would have been tolerable for a vehicle driver with normal eyesight.

77 The poor condition of the backboards, in combination with falling sunlight, reduced the conspicuity of the lights to any approaching road vehicle. Although unlikely to have significantly affected someone with standard eyesight, this was of particular significance to a road vehicle driver with sub-standard eyesight and a greater susceptibility to the effect of glare.

Figure 7: Condition of road traffic light signals, Halkirk crossing, south side

78 Figure 8 shows the effect of sunlight on the road traffic light signals, with the sun in the same position as it was at the time of the accident. This effect was investigated further with respect to the condition of the backboards and the amount of *contrast* between them and the lit red light units of the road traffic light signals. The difference long hoods would have made, had they been fitted, was also investigated.

79 The optical tests (paragraph 41) carried out found that only a small area of each lit red light unit would have been affected by sunlight at the angles associated with viewing the lights at the time of the accident (figure 8). These show a small crescent at the base of the lens and an arc shaped reflection from inside the hood. Therefore, the effect of sunlight swamping the red light units was not likely to have been a significant factor.

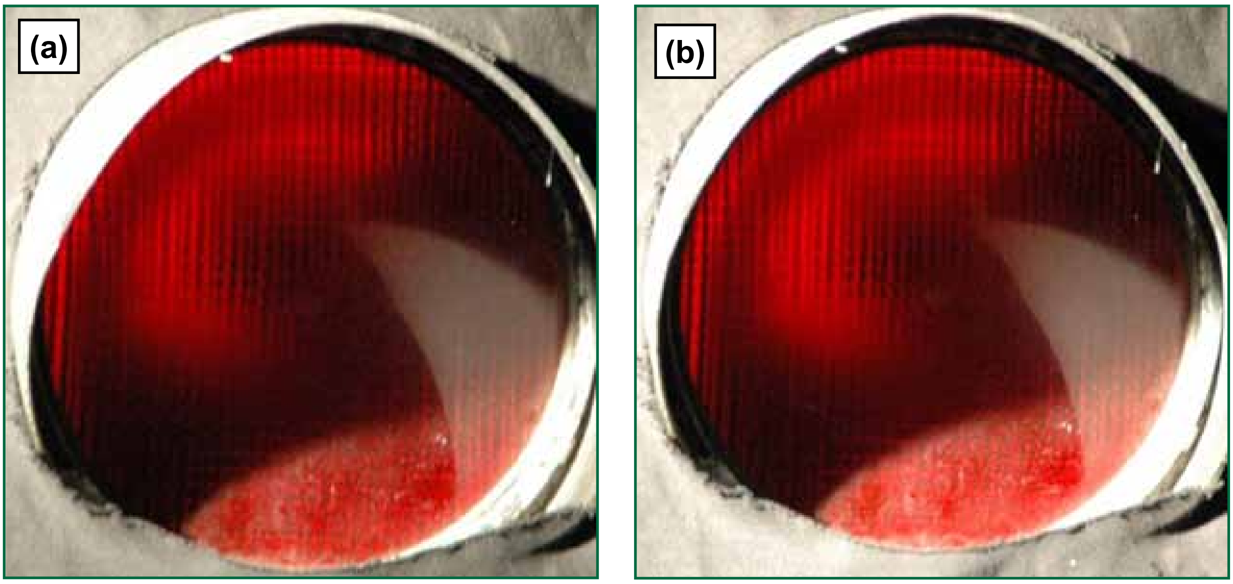

Figure 8: The effect of sunlight on the near side road traffic light signal red light units during tests from (a) 100 metres and (b) 50 metres

80 However, the optical tests found that the condition of the backboards was such as to reduce the amount of contrast between the lit red light units and the areas of the backboards, an effect that was more significant in the case of the right-hand backboard. This reduced the conspicuity of the lights.

81 Network Rail's routine inspection of 22 April 2009 (Appendix D, paragraph 27) noted that both the south side road traffic light signal chequered red and white borders were unsatisfactory: the nearside backboard was starting to rust and the off side backboard was faded. The defect was allocated a priority in accordance with Network Rail's procedures for the work to be completed within six months. A work arising form was completed on 24 April 2009 for action by the signal maintenance function. Remedial action was not taken before the next inspection, and the same defects were noted at the following inspections on 2 June and 21 July 2009. New work arising forms were completed duplicating the one that had been completed on 24 April 2009 and allocating the same priority for the work to be completed within six months.

82 The signal maintenance function did not take action in response to the work arising forms because they were waiting for the start of a project sponsored by Network Rail headquarters to upgrade the road traffic light signals at crossings identified as highest risk to LEDs. This project included converting most AOCLs.

83 The inspection checklists used by staff carrying out inspections of level crossings only required that a check was made 'that the road signals, and their associated hoods, are in acceptable condition'. The maintenance specification applicable to the crossing required a check of the backboard but emphasised that the check related to damage and the proper security of the road lights. There was no direct requirement to check that the colour of the backboard was providing the best contrast with each lit red light unit.

The conspicuity of the road traffic light signals - the effect of misalignment of the nearside road traffic light signals

84 Following the accident, RAIB inspectors on site found that the nearside road traffic light signal was misaligned: at a point 100 metres from the crossing stop line, and at normal eye level, they determined that it was aligned to a point about 7 metres to the right of the carriageway centreline, or 10 metres from the nearside edge of the carriageway. The offside road traffic light signals were determined to be correctly aligned. There was no discernible difference between the alignments of the two red light units within either road traffic light signal.

85 The extent to which this misalignment affected the conspicuity of the road traffic light signals was measured as part of the optical tests with reference to the standard alignment (misalignment is required to be checked during routine inspections and maintenance of the crossing: Appendix D, paragraphs 26 to 37).

86 The tests showed that at 100 metres away, the nearside road traffic light signals would have delivered a luminous intensity that was 79% of that delivered by the standard alignment. Closer to the lights, the luminous intensity would have been greater than that delivered by the standard alignment (e.g. at 50 metres away, the standard alignment would have had a luminous intensity 90% that of the misaligned road traffic light signals).

87 The misalignment of the nearside road traffic light signals is therefore likely to have had a small detrimental effect on their overall conspicuity when viewed from a distance but would have improved it when closer to the crossing. Overall, the effect of the misalignment of the nearside road traffic light signals was considered to be negligible and not contributory to the accident.

The 30 mph speed restrictions signs on the south side road approach to Halkirk level crossing

88 The specialist human factors consultant commissioned by the RAIB advised that the commencement of the 30 mph (48 km/h) speed limit close to the crossing on the south side (figure 9) could be a distraction to motorists approaching the crossing. This proximity of the speed limit signs to the crossing might reduce the attention given to the crossing, or remove attention away from it completely. The signs might also draw a car driver's attention to the vehicle speedometer to check vehicle speed and away from maintaining vision out of the vehicle's windscreen. Other signs in the vicinity of a level crossing that are not related to that crossing could also be a potential distraction.

Figure 9: the 30 mph signs at Halkirk crossing (taken after the accident and the renewal of the road lights to the LED type)

The car driver did not understand the crossing signs and flashing road traffic light signals

89 It is possible that having seen the road traffic light signals, the car driver misinterpreted the meaning given by the level crossing signs and road traffic signals associated with Halkirk level crossing. In this scenario, even though the road traffic signals were visible, they could be discerned and the car driver was observing them, he might have driven onto the crossing believing that the flashing road traffic signals indicated that it was safe to cross.

90 The 1996 study carried out by the Transport Research Laboratory[16] (paragraph 52) found that motorists had a poor knowledge of the meaning of the sign denoting a level crossing without barrier or gate ahead, and a significant proportion did not properly understand the meaning given by the road traffic light signals. Only 54% of those questioned were able to correctly state the meaning of the flashing red lights compared with 100% of those questioned who knew the meaning of a normal red traffic light signal at a road junction.

91 Road users encounter flashing red road traffic light signals at level crossings far less frequently than other signals such as traffic lights, and some drivers might believe that the lights have to display a steady red to mean stop, and that flashing red means it is permissible to drive onto the crossing (see the RAIB's report on its investigation of the accident at Wraysholme AOCL on 3 November 2008 (report 26/2009, paragraphs 95 to 98)).

92 It is possible therefore that the car driver thought that he could proceed when the lights were flashing with the expectation that they would change to steady red to mean stop.

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[16] Vehicle Driver Behaviour at Level Crossings, HSE Contract Research Report No. 98/1996, HSE Books, ISBN 0-7176-1093-4.

93 The car driver had passed his driving test at an unknown date before 1974, and might not have refreshed his memory of the meaning of the signs and signals at level crossings (paragraphs 26 and 27) since he took his test. However, the evidence is that he would have driven over level crossings previously, given the number to be found on the railways north, east and west of Inverness where he lived, but it is not known how many level crossings he approached that were operating because a train was approaching. The RAIB considers it is unlikely that the car driver saw and then misinterpreted the road traffic light signals.

The car driver ignored the instruction to stop

94 It is also possible that the car driver did not see the flashing road traffic light signals until he was too close to the crossing to be able to stop safely before it. The car driver should have slowed down in accordance with the 30 mph signs, located 21 metres before the crossing stop line (paragraph 16), in which case, according to the Highway Code, the car's stopping distance would typically be 23 metres.

95 If the car driver only saw the level crossing flashing lights after having slowed to the 30 mph signs, he could have thought that he had insufficient stopping distance remaining and decided to carry on over the crossing. There was no evidence of any tyre skid marks to suggest that the car driver had attempted any sudden emergency braking (Appendix D, paragraph 11).

96 The RAIB has judged that it was unlikely the car driver committed a violation and deliberately drove past the flashing lights in combination with sufficient time to stop before the crossing. There is no evidence that the occupants of the car were in a hurry and with a clean driving licence (Appendix D, paragraph 2) it seems unlikely that the car driver was prone to taking undue risks.

Identification of underlying factors[17]

Assessment of risk and the implementation of risk reduction measures

97 **The risk at Halkirk level crossing was not properly understood because the crossing's previous incident and accident record was not taken into account by Network Rail when determining whether risk reduction measures were reasonably practicable. As a consequence:**

- **more costly risk reduction measures might have been justified (such as upgrading the crossing by fitting barriers) if all the relevant factors at Halkirk crossing had been taken into account; and**
- **risk reduction measures that had been identified as a result of risk assessments were not implemented with any degree of urgency and not by the time the accident occurred on 29 September 2009.**

[17] Any factors associated with the overall management systems, organisational arrangements or the regulatory structure.

Before the introduction of the All Level Crossing Risk Model (ALCRM)

98 Network Rail first assessed Halkirk crossing using a quantitative method developed for automatic crossings in 2002. This was based on a traffic census carried out on 14 February 2002 between 10:00 hrs and 11:00 hrs which recorded 13 cars and 8 vans/small lorries and equivalent to a daily count of 176 and 108 respectively. A rail traffic level of 11 trains a day was assumed.

99 The risk to road users was calculated to be 1 in 150,000 (the level of tolerable risk being defined as 1 in 100,000). Network Rail revised this to 1 in 79,000 following the accident on 18 October 2002 (paragraph 55), and a site visit on 18 December 2002 that found many road users exceeded the 30 mph (48 km/h) speed limit over the level crossing. This level of risk was sufficient to cause Network Rail to consider options that would improve the level of safety.

100 Network Rail carried out cost benefit studies on three options:

1. Upgrade the crossing to an *automatic barrier crossing, locally monitored* (ABCL). Network Rail concluded that this was not *reasonably practicable*.
2. Extend the 30 mph (48 km/h) speed restriction applying to the south side road approach to the 'STOP when lights show' sign and fit *extended hoods* to the road traffic light signals. Network Rail concluded this was reasonably practicable.
3. Extend the 30 mph (48 km/h) speed restriction applying to the south side road approach to the 'STOP when lights show' sign, provide rumble strips and fit extended hoods. Network Rail concluded this was reasonably practicable.

101 The measures in options 2 and 3 above were not implemented, but the RAIB has been unable to determine why. Implementation of these measures might have reduced the likelihood of the accident occurring on 29 September 2009, although the optical tests (paragraph 78) found that the fitment of long hoods would have been unlikely to have made a difference.

Risk assessment using ALCRM

102 Since January 2007 Network Rail's procedures required the use of the All Level Crossing Risk Model to assess the risk at level crossings, supported as necessary by expert judgement, local knowledge or additional risk assessment processes where appropriate. This is a computer model on a central database which predicts the risk level at level crossings based on the input variables which are entered following the collection of data from site. It gives an output in two forms:

- the individual risk level measured as the computed probability of fatality per year that an individual is exposed to from the operation of the railway on a scale of A (highest) to M (lowest); and
- the collective risk level computed as the average number of fatalities and weighted injuries (FWI) per year (a FWI is based on one fatality = 10 major injuries = 200 minor injuries) that would be expected to occur on a scale of 1 (highest) to 13 (lowest).

103 Where the collective risk level is in the range 1 to 3, or the contribution of train accident risk to the total risk at the level crossing is above 50%, Network Rail required that an operations risk control co-ordinator (ORCC) carried out a site visit to assist in the identification of issues and to identify possible risk reduction measures[18].

104 In the case of Halkirk crossing, the assessment was carried out on data collected on 18 September 2007. This was based on rail traffic levels of eight trains a day and road traffic levels that were measured during a minimum 30 minute period (as required by Network Rail's procedures and known as a quick census) starting from 13:30 hrs. Thirteen cars, seven vans/small lorries, one heavy goods vehicle and two pedestrians were noted which the model calculated equated to a 24 hour vehicle count of 567. Using the collected data, the model gave an output of D3, requiring a site visit to be carried out.

105 Guidance on possible risk reduction measures is given by the level crossing risk management tool kit (www.lxrmtk.com) developed by Human Engineering Ltd on behalf of the RSSB. Network Rail's procedures require that this is used to investigate possible options to reduce the risk. ALCRM can then be used to carry out a cost benefit analysis which compares the safety benefit of a possible risk reduction measure with the cost of its implementation.

106 The ORCC made the site visit to Halkirk crossing on 26 March 2008. The risk reduction measures identified, which gave a positive safety benefit over costs, were to install rumble strips on the highway approaches and reduce the crossing speed to 35 mph (56 km/h) in accordance with the Stott report (see Appendix C). Upgrading the crossing to one with barriers did not meet Network Rail's cost benefit criteria and was not taken forward.

107 Network Rail's procedures require that its staff consider other relevant information, such as the record of incidents and accidents at the crossing concerned, and do not rely solely on the results of the cost benefit analysis to decide whether or not to take forward risk reduction measures. However, the procedures do not give guidance on how the record of incidents and accidents should be used to supplement the information given by ALCRM to understand the risk, or to inform decisions on implementing risk reduction measures.

108 The cost benefit analysis did not support the case for upgrading Halkirk crossing to one with barriers but the previous accident record of four collisions before the accident on 29 September 2009 (paragraph 55) was not considered. If the accident record of Halkirk crossing had been taken into account to get a better understanding of the risk, it might have provided a much stronger case for upgrading the crossing.

[18] There is a fuller description on Network Rail's use of ALCRM in Appendix B of the RAIB's report on its investigation of the fatal accident at Fairfield crossing, Bedwyn, 6 May 2009 (report 08/2010).

Revisions to the risk assessment

109 ALCRM was rerun in September 2008 because of an expected increase in rail traffic from 8 to 12 trains per day. The resulting output was D2 and used the data from a further quick census carried out on 1 September 2008 from 13:50 hrs. This recorded 13 cars and seven vans/small lorries equating to 540 vehicle movements per day. Network Rail believed that the increase in collective risk level occurred because of the increase in the number of trains (which subsequently did not materialise) put into the model. Options considered were to reduce the crossing speed in accordance with the Stott report and install extended hoods to mitigate the effect of sunlight falling on the road traffic light signal red light units. With these measures in place, the risk level would be reduced to D4.

110 Network Rail also carried out a full 24 hour census over seven days in August 2008 in order to support the introduction of Stott crossing speeds at Halkirk but used the data from the quick census in the September 2008 rerun of ALCRM. Traffic levels from the full census were on average 1188 vehicles a day showing that use of the quick census at Halkirk crossing might have significantly under-estimated the actual road traffic levels, although it is also possible that an increase was explained by more road traffic using the crossing during the peak holiday season. A rerun of ALCRM using the full traffic data, the proposed reduction in train speed to 35 mph (56km/h) and the fitment of extended hoods resulted in an increased risk level back to D3.

111 Running ALCRM after the accident, for the circumstances that existed at the time of the accident: 1188 vehicles a day (assuming this was still valid, having been measured in August 2008), 50 mph (80 km/h) crossing speed, 8 trains a day and 50W halogen road traffic light signals. For these conditions, the risk level produced by ALCRM was D2. Changing the road traffic light signals to the LED type after the accident reduced the risk level to D4.

Implementation of risk reduction measures

112 The proposed reduction in train speed to 35 mph (56 km/h), in accordance with the Stott report, was not implemented until after the accident occurred on 29 September 2009 (described more fully in paragraphs 126 to 129).

113 Rumble strips (rumble devices) had been identified as a possible risk reduction measure and it is possible that they could have compensated to a degree for the car driver's poor eyesight if they had been fitted to the southerly highway approach to the crossing.

114 Traffic Advisory Leaflet 11/93 'Rumble Devices' published by the Department for Transport states that rumble devices can be used, usually in rural areas, to alert drivers to take greater care in advance of hazards such as a bend or junction. Their purpose at Halkirk crossing would have been to provide road vehicle drivers with an auditory and tactile warning of the presence of the level crossing ahead, prompting them to look at the flashing lights (paragraph 54).

115 The level crossing risk management toolkit (paragraph 105) also includes the use of rumble strips as a risk mitigation measure at level crossings, particularly where there are long, straight road approaches or where the road descends to the grade of the railway on one or both sides of the railway. The toolkit states that the rumble strips should be in line with the position of the advance warning signs (paragraph 26).

116 Network Rail contacted Highland Council to request that rumble strips should be fitted to the southerly highway approach to Halkirk crossing following the accident on 18 October 2002, (paragraph 55).

117 Highland Council rejected the use of rumble strips because of the possible disturbance to local residents. This was based on advice contained in Traffic Advisory Leaflet 11/93 which states that, in general, the installation of rumble strips close to residential properties should be avoided. The leaflet further stated that where there was likely to be a conflict between safety gains and increased noise levels, an assessment should be carried out to determine whether the disbenefits of increased noise were outweighed by the safety gains.

118 Highland Council did not carry out any assessment as they considered there were alternatives to rumble strips such as countdown markers and anti-skid surfacing. These measures were recommendations made in Railtrack's report on the 2002 accident (paragraph 57, table 1), with the intention of increasing the conspicuity of the crossing and therefore influencing road users' awareness of it, and were still being discussed with Network Rail at the time of the 2009 accident. However, such measures are aimed primarily at reducing the speed of approaching road vehicles rather than alerting drivers to a hazard ahead. The RAIB did not find any assessment that their benefit would be similar to that of rumble strips.

119 It is possible that the use of rumble strips might have been ineffective in that they alerted road vehicle drivers to the 30 mph signs and not to the level crossing.

120 Under Network Rail's procedures, the only additional action required when ALCRM produces high risk levels is that a site visit must be made to further inform the process of identifying possible risk reduction measures (paragraph 103). The purpose of ALCRM is to enable risk reduction measures at level crossings to be prioritised based on their risk levels.

121 A full understanding of the risks at a level crossing is fundamental to the determination of appropriate risk reduction measures that are implemented to a timescale that is commensurate with the risk. Risk reduction measures had been identified to reduce the risk at Halkirk crossing, but only those relating to re-painting road markings and replacing signs (table 1) had actually been implemented by the time the accident occurred on 29 September 2009 despite having been considered since 2002.

122 During the period from 2002 to 2009 there were several staffing changes and reorganisations within the Network Rail department in Scotland dealing with the risk management of level crossings and it is likely that this led to a loss of focus in the implementation of risk reduction measures. The introduction of ALCRM in January 2007 also resulted in the acquisition of data for the model being a priority which might have caused other work to be delayed.

123 If the risk had been properly understood, the risk reduction measures might have been implemented with greater urgency and more costly risk reduction measures might have been justified.

124 The RAIB has commented on deficiencies in the process used to risk assess level crossings and implement risk reduction measures in previous RAIB reports on investigations of fatal accidents at level crossings:

- Accident at West Lodge crossing, Haltwhistle, on 22 January 2008 (report 01/2009): there was a failure to act to reduce the risk that had been identified arising from the inadequate sighting of approaching trains.
- Accident at Wraysholme crossing, Flookburgh, Cumbria on 3 November 2008 (report 26/2009): there was a failure to investigate suitable risk reduction measures to reduce the identified risk arising from the sun.
- Accident at Moor Lane crossing, Staines, on 16 April 2008 (report 27/2008): the risk assessment did not identify the risk of slipping on the crossing.
- Accident at Fairfield crossing, Bedwyn, on 6 May 2009 (report 08/2010): the risk assessment did not take sufficient account of the lack of adequate sighting of approaching trains, or the inadequate instructions which made the telephones provided at the crossing ineffective.

Discounted factors

125 The RAIB has concluded that the following additional factors had no effect on the outcome of the accident and have therefore been discounted. More information about these factors is contained in Appendix D.

- The car driver was competent to drive, and apart from his eyesight (paragraphs 65 to 70), was medically fit to drive a motor vehicle.
- The car was examined by the Northern Constabulary who found there were no issues concerning the condition of the car.
- There were no factors concerning the performance of the train or the way it was driven; the train driver could not have avoided the accident or affected its outcome.
- The level crossing was tested after the accident and found to operate as it was designed to do.
- There were no issues concerning the advance warning signs, on the south side road approach to the level crossing, that inform vehicle drivers that a level crossing without gates or barriers is ahead, and to stop when the road traffic light signals show.
- The system of routine crossing inspections carried out by Network Rail was correctly followed in accordance with Network Rail's procedures, although remedial work to the backboards was assigned a priority to be completed within six months, at successive inspections, by the level crossing inspection team (paragraph 81).
- The system of level crossing maintenance was carried out correctly, although reports about the poor condition of the traffic light signal backboards arising from the routine level crossing inspections were not acted upon immediately, because of the planned renewal of the backboards in conjunction with an upgrade of the lights to LEDs (paragraph 82).

Severity of consequences

126 Reducing the crossing speed for trains to 35 mph (56 km/h) was one of the options Network Rail considered as part of the ALCRM process, and this was further reinforced by a letter from the Office of Rail Regulation (ORR) to Network Rail in January 2009, stating that the ORR expected level crossings to comply with the Stott criteria, although no timescale was set for implementation.

127 The crossing speed for passenger trains at Halkirk crossing was initially to be reduced from 50 mph (80 km/h) to 40 mph (64 km/h) and implemented by means of a temporary speed restriction in the interim before permanent arrangements could be made. The temporary lineside signs to advise train drivers of the speed were ordered for the crossing but, before any implementation, the crossing speed was then further reduced to 35 mph (56 km/h) based on a re-assessment of the level of rail traffic on the line. The maintenance department in Network Rail responsible for procuring and erecting the boards was advised, but the new speed signs reflecting this change in speed were not ordered and the error went unnoticed for about three months. As a consequence, it was not until after the accident occurred on 29 September 2009 that the lower Stott crossing speed was introduced.

128 It is not possible to state with any degree of certainty whether the reduced crossing speed would have made any difference to the outcome of the accident.

129 The question of what train speeds would guarantee a reasonable chance of the survival of the occupants of a road vehicle when struck by a train will be considered in the RAIB's separate class investigation of AOCLs.

Additional observations

130 From witness evidence, the Network Rail staff carrying out level crossing inspections did not understand the difference between visibility and alignment. Visibility is related to whether the road traffic light signals can be seen, whereas the alignment is correct when they can be seen at their brightest at a pre-defined position at a specified distance. Witness evidence was that the road traffic light signals were checked to ensure they were visible and not obscured by, for example, vegetation. This check was sometimes carried out when the road traffic light signals were not operating, because the inspections were undertaken when no trains were due.

131 The misalignment of road traffic light signals was a factor in the fatal accident at Wraysholme level crossing, Flookburgh, Cumbria on 3 November 2008 (RAIB report 26/2009). Network Rail staff could not align the south side road traffic light signals to the standard alignment because of a bend in the road approaching the level crossing. They were therefore aligned to a point from which they were visible but which was not optimised. At the time of the accident, Network Rail had no procedure for optimising alignment. This was corrected by the issue of Technical Instruction TI 136 'Alignment of Level Crossing Road Traffic Light Signals (Road traffic light signals)' issued in April 2009. Witness evidence was that this instruction had not been received and briefed in the Perth area responsible for inspecting Halkirk level crossing.

132 The optical tests (paragraph 41) found that with the sun position as it existed at the time of the accident, the standard hoods fitted to the red light units of the road traffic light signals (figure 4) were more effective than would have been the case had long hoods been fitted. With standard hoods, a high level of contrast was measured between the lit and unlit red light units with only a small area of each light unit affected by sunlight (figures 8a and 8b). This contrast would have been reduced with long hoods because the light from the sun in the position it was at the time of the accident would have struck a larger area of the lens, because a long hood has more open sides than a standard hood. Long hoods are therefore not more effective in mitigating the effect of sunlight falling on the road traffic light signals for all sun angles.

133 The fact that long hoods were not fitted at the time of the accident, despite the recommendation to fit long hoods following the 2002 accident (paragraph 57), had no bearing on the 2009 accident.

Conclusions

Immediate cause

134 The driver of the car did not react to the road traffic light signals and drove onto the level crossing at the same time as the train arrived.

Causal factor

135 The most likely causal factor was that the car driver did not react to the flashing road traffic light signals because he did not see them. Feasible explanations for this are a combination of 135a to 135c below:

a. the car driver had sub-standard eyesight (**paragraphs 65 to 70, no recommendation**);

b. the conspicuity of the road traffic light signals was reduced by the poor condition of their backboards, giving rise to a greater susceptibility to glare in a road vehicle driver with sub-standard eyesight (**paragraph 77, Recommendation 1**); and

c. the 30 mph (48 km/h) speed restriction signs for road vehicles on the south approach to the level crossing might have been a distraction to road vehicle drivers (**paragraph 88, Recommendation 2**).

While it is not possible to state the relative significance of each one with certainty, it is likely that the car driver's sub-standard eyesight was the most significant factor. There are other possible explanations for which there was no evidence (such as something causing a distraction in the car) which cannot be entirely ruled out.

Underlying factor

136 An underlying factor was that Network Rail did not fully understand the risk at Halkirk level crossing because the crossing's previous incident and accident record was not taken into account in determining whether risk reduction measures were reasonably practicable. As a consequence:

a. more costly risk reduction measures might have been justified (such as upgrading the crossing by fitting barriers) if all the relevant factors at Halkirk crossing had been taken into account and there had been guidance on how they should be considered (**paragraphs 107 and 108, Recommendations 3 and 4**); and

b. risk reduction measures that had been identified as a result of risk assessments were not implemented with any degree of urgency, and not by the time the accident occurred on 29 September 2009, due to a loss of focus within the Network Rail organisation (**paragraphs 121 and 122, no recommendation, see paragraph 143**).

Additional observations[19]

137 The following additional observations were noted:

a. There was confusion among the staff undertaking level crossing inspections about the difference between visibility and alignment (**paragraph 130, Recommendation 5**).

b. The current design of long hoods fitted to road traffic light signals does not mitigate the effect of falling sunlight for all sun angles (**paragraph 132, Recommendation 6**).

[19] An element discovered as part of the investigation that did not have a direct or indirect effect on the outcome of the accident but does deserve scrutiny.

Actions reported as already taken or in progress relevant to this report

138 Network Rail carried out its own investigation of the accident, but had no access to evidence collected by the police authorities relating to the car or its driver. It concluded that the immediate cause of the accident was that the car wrongly moved onto the crossing which operated correctly for the train. Two underlying causes were identified:

- the driver of the car failed to control his car in response to the road traffic light signals, signs and circumstances presented to him as the car approached the crossing; and
- low sun in the sky behind the car driver shining towards the crossing at the time of the accident might have affected the car driver's view of the level crossing's signals and signs as his car approached the crossing.

139 Network Rail identified in its own investigation that the results from a full census of vehicle movements showed different traffic levels from a quick census (paragraph 110). It has made a recommendation that Network Rail should consider in future only using the full census.

140 Following the accident, Network Rail fitted LED road traffic light signals, including new backboards and chequered surrounds, at Halkirk level crossing. When they are flashing, these are more conspicuous to an approaching road user than the 50 Watt halogen lamps previously fitted.

141 Also, following the accident, Network Rail reduced the crossing speed applicable to passenger trains at Halkirk level crossing from 50 mph (80 km/h) to 35 mph (56 km/h) (paragraphs 126 to 128). This was initially implemented as a temporary speed restriction before the necessary changes (changing the location where an approaching train activates the crossing and new signage) were made to convert it to a permanent speed restriction.

142 Network Rail has also established road-rail partnerships with local authorities in many parts of the country, including with Highland Council. These provide a forum in which matters concerning the road-rail interface may be discussed and the progress of improvement measures monitored. This should make the sort of delays in implementing the risk reduction measures described in paragraphs 113 to 117 less likely to occur.

Previous recommendation relevant to this investigation

143 The following recommendation was made by the RAIB as a result of a previous investigation, which addresses the factors identified in paragraph 136b. It is therefore not remade so as to avoid duplication:

Fatal accident at West Lodge crossing, Haltwhistle, 22 January 2008, RAIB report 01/2009

Recommendation 3

Network Rail should revise its management systems so that the findings of level crossing inspections and assessments are acknowledged, prioritised and acted upon to provide arrangements that adequately protect users.

Recommendations

144 The following safety recommendations are made[20]:

Recommendations to address causal and contributory factors

1 *The intention of this recommendation is that Network Rail should maintain the backboards fitted to road traffic light signals at level crossings so as to maximise the contrast between the lit red light unit and the backboard.*

Network Rail should enhance the maintenance and inspection instructions relating to road traffic light signals, and brief staff accordingly, with the objective of ensuring that the backboards to level crossing road traffic light signals are maintained to provide the best possible contrast between a lit red light unit and its backboard (paragraph 135b).

2 *The intention of this recommendation is that Network Rail should take into account the human factors issue of highway speed limit and other signs positioned close to level crossings while assessing the risk.*

Network Rail should consider amending the level crossing risk management toolkit to include the human factors issue and associated risk reduction measure relating to the potential distraction caused by highway speed limit signs and other signs positioned close to level crossings (paragraph 135c).

continued

[20] 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 167 to 171) can be found on RAIB's web site at www.raib.gov.uk.

Recommendations to address underlying factors

3 *The intention of this recommendation is that Network Rail should obtain a full understanding of the risk at Halkirk crossing with the result that more costly risk reduction measures such as the installation of half barriers might be justified.*

Network Rail should obtain a full understanding of the risk at Halkirk level crossing by taking account of all relevant local factors such as the accident and incident history, as well as the results from ALCRM. The results of this assessment should be used to determine whether it would be reasonably practicable to upgrade the crossing with half barriers, or to implement other measures to deliver an equivalent level of safety (paragraph 136a).

4 *The intention of this recommendation is that those who execute the level crossing risk management process have sufficient guidance on how to assess the risks from factors not included in the All Level Crossing Risk Model assessment, including taking into account local factors such as the previous incident and accident history.*

Network Rail should issue improved guidance, and brief its staff, on assessing the risk from factors that are not currently included in the All Level Crossing Risk Model when carrying out risk assessments and making decisions on implementing risk reduction measures at crossings. This should include methods to be adopted when taking into account local factors such as the previous incident and accident history (paragraph 136a).

Recommendations to address other matters observed during the investigation

5 *The intention of this recommendation is to make staff carrying out level crossing inspections and maintenance aware of the difference between the visibility of road traffic light signals and their alignment and how they may determine that the lights are correctly aligned.*

Network Rail should improve the guidance to staff and brief its staff who undertake the inspection and maintenance of level crossings on how they should check that road traffic light signals are correctly aligned and how this differs from them being visible (paragraph 137a).

6 *The intention of this recommendation is to cause Network Rail to change the design of long hoods so that they are more effective and to give its staff guidance on the criteria under which they should be fitted.*

Network Rail should review the design of long hoods that can be fitted at level crossings and implement any necessary changes identified to make them more effective. Guidance should also be issued to its staff on the specific circumstances of site orientation and prevailing lighting so that their use is optimal (paragraph 137b).

Appendices

Appendix A - Glossary of abbreviations and acronyms

ABCL	Automatic Barrier Crossing, Locally Monitored
ALCRM	All Level Crossing Risk Model
AOCL	Automatic Open Crossing, Locally Monitored
AOCR	Automatic Open crossing, Remotely Monitored
LED	Light emitting diode
ORR	Office of Rail Regulation
RSSB	Rail Safety and Standards Board
SMIS	Safety Management Information System

Appendix B - Glossary of terms

Automatic Barrier Crossing, Locally Monitored	A form of level crossing protection that is effectively an AOCL with the addition of half barriers. The train driver still has to monitor the crossing on approach but for a road user there is no apparent difference from an automatic half barrier crossing.
Automatic Open Crossing, Remotely Monitored	The same as an AOCL from the road user's perspective but there is no requirement on the train driver to monitor the crossing as a train approaches it. The equipment at the crossing is monitored e.g. from a signal box, and emergency telephones are provided for the use of the public. There is only one example left that is fitted at Rosarie, Moray.
Conspicuity	A subjective term which relates to the ability of an object to capture attention. It is related to the amount of contrast present between the object and its background.
Contrast	The difference in colour and brightness that makes an object stand out from other objects or its background.
Countdown markers	A sign at the side of the road that displays three, two or one diagonal bars to indicate to vehicle drivers how far it is to a hazard ahead.
Crossing speed	The permitted maximum speed applicable to a train approaching and passing over an AOCL or ABCL.
Diesel multiple unit	A diesel powered train consisting of one or more coaches with a driving cab at each end and which can couple to other multiple units and control them from the leading cab.
Earth testing	Testing to ensure that current leaking to earth from a conductor is below specified limits.
Effective Traffic flow	Road traffic flow at a level crossing reduced to take account of the barrier effect caused by a vehicle stopping at the crossing and preventing following vehicles that might otherwise cross from doing so.
Ellipse database	A Network Rail computer database that records maintenance work carried out on the infrastructure and schedules when maintenance is next required.
Extended hoods	Hoods longer than standard, fitted above the individual lamps of level crossing road traffic light signals, to shade the lamps from falling sunlight.
Level crossing order	A legal order made under the Level Crossings Act 1983 which specifies the particulars to be provided at a level crossing.
Luminous intensity	The power emitted by a light source in a particular direction.
Office of Rail Regulation	The safety regulator for the railways in Great Britain.

Open crossing	A level crossing that is unprotected by either barriers or road traffic light signals. Vehicle drivers must give way to trains.
Reasonably practicable	Determining whether something is reasonably practicable involves weighing the risk on the one hand against the sacrifice (money, time or trouble) needed to avert the risk. This is more than comparing the safety benefit of a measure with its cost (a cost benefit analysis) because the risk reduction measure should be implemented unless it requires a sacrifice that is grossly disproportionate.
Relay	A device containing an electromagnet that is used to make or break sets of electrical contacts when it is energised or de-energised.
Rumble strips	A road safety feature to alert vehicle drivers to a hazard ahead by means of vibration and audible rumbling.
Safety Management Information System	A computer database used by the railway industry to record incidents and accidents.
Track circuit	An electrical circuit in the running rails that detects the presence of a train.
Treadle	A switch operated by a lever when depressed by a railway wheel passing over it.
Wire count	A visual examination to ensure that the correct number of wires is connected to each terminal as shown on the wiring diagram.

Appendix C - The history of AOCLs

1 AOCLs were first introduced in 1963 with a maximum train speed of 35 mph (56 km/h). Following a report by a working party of officers of the Department of Transport and of the British Railways Board[21] published in 1978, this was changed so that the maximum train speed over an AOCL should be related to the braking distance from which the train driver can have a satisfactory view of the crossing. A maximum speed of 55 mph (88 km/h) was also set.

2 The number of AOCLs installed on the railway network increased rapidly until the accident at the AOCR at Lockington, Yorkshire, on 26 July 1986, when a passenger train struck a van and derailed. Eight passengers on the train and a passenger in the van were killed.

3 Concern over the safety of automatic open crossings led to a review. This was conducted by Professor P F Stott and his report was published in 1986[22]. At that time, there were around 200 AOCLs and 40 AOCRs on the British Rail network. Professor Stott argued that for a given number of trains, the probability of a collision is not proportional to the amount of road traffic because at high levels of road traffic, once a vehicle stops at the crossing, it will form a barrier to any following vehicles that might otherwise drive onto the crossing into the path of an approaching train. Collision risk was therefore said to be proportional to what was termed *effective traffic flow* – traffic flow reduced by an amount to take account of the barrier effect. Effective traffic moment is the product of the number of trains and the effective traffic flow.

4 Professor Stott proposed that while the maximum speed for trains at an AOCL should remain at 55 mph (88 km/h), this speed should be reduced with increasing effective traffic moment. The same logic would also apply to AOCRs whose maximum rail speed was 75 mph (121 km/h). Automatic open crossings falling outside these limits were to be converted to other forms of level crossing protection.

5 Following the publication of the Stott report, British Rail converted all but one of the AOCRs, mainly to automatic half barrier crossings. Many AOCLs have also been converted to either automatic half barrier crossings or *automatic barrier crossings, locally monitored* (ABCLs). In general, AOCLs are now to be found in two main areas: rural locations where road traffic levels are low, and industrial/urban situations where train frequency and speed is low, although there are some exceptions to this.

6 The limits on road and rail traffic levels at AOCLs proposed in the Stott report were incorporated into the ORR's guidance on level crossings (paragraph 20). The ORR uses the guidance in its assessment and approval of upgraded level crossings.

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[21] Level Crossing Protection, Report by Officers of the Department for Transport and of the British Railways Board, HMSO 1978, ISBN 0115504826.

[22] P F Stott: Automatic Open Level Crossings – A Review of Safety, HMSO 1987, ISBN 0115508317.

Appendix D - Factors that were discounted

The driving of the car onto the level crossing

1 There is no evidence that the car driver deliberately ignored the flashing road traffic light signals and drove onto the crossing when there was still sufficient distance in which to stop before it (paragraph 96).

2 According to records from the Driver and Vehicle Licensing Agency going back to 1974, the car driver was issued with a driving licence before that year, with witness evidence stating that he had been driving since at least 1958. He had no recorded motoring convictions, suggesting he was not a habitual risk taking driver.

The car driver's fitness to drive

3 Apart from the car driver's eyesight (paragraphs 65 to 70), the RAIB has concluded that there is no evidence to suggest that the car driver's fitness was a factor that increased the likelihood of the accident.

4 Although the car driver had driven from Inverness, there was no evidence that he was fatigued, either from lack of sleep the previous night, or from the length of the journey. The conditions on the day of the accident for driving were good, and it was a journey that the car driver had made regularly. The journey had also been broken while the car driver and his wife collected the car driver's brother from Latheron (paragraph 28).

5 The post mortem report on the car driver found no evidence of any medical condition or occurrence that contributed to the outcome of the accident. He also tested negative for the presence of any alcohol or drugs

6 The car driver was 81 years old (paragraph 8). Increasing old age increases the risk of accident because of the slowing of thinking, increasing reaction times and reductions in strength and flexibility. However, the group of drivers with the highest crash risk is young males during the first few years after they have passed their driving test[23]. By comparison, the increase in risk with age is trivial compared with the risk in the young and inexperienced driver. Older drivers are therefore generally competent and will often restrict their driving voluntarily if necessary, e.g. by no longer driving at night, restricting their driving to areas with which they are familiar, etc.

The car and its operation

7 The RAIB has concluded that there was nothing concerning the condition of the car that affected the outcome of the accident.

8 The car was examined by the Road Policing Unit of the Northern Constabulary. Aside from the damage sustained in the collision, the vehicle was found to be in good condition and to have no defects that could have contributed to the outcome of the accident. Checks included the braking system, which was found to function correctly.

9 No clear evidence is available concerning the speed of the car as it approached the level crossing, which would have come into clear view along the straight section of road when the driver was 350 metres from the road traffic light signals.

[23] Fitness to Drive: A Guide for Health Professionals, Department for Transport, ISBN 1-85315-651-5.

10 Assuming that the car was travelling at the road speed limit of 60 mph (97 km/h), and it correctly reduced its speed to 30 mph (48 km/h), in accordance with the speed limit signs before the crossing, calculations by the RAIB show that when the level crossing first came into view, the road traffic light signals would already have been operating displaying the flashing red lights.

11 A train approaching from the car driver's left-hand side would not have been visible to the car driver until the car was 22 metres from the centre of the railway, which is less than the 23 metres typical stopping distance for a vehicle travelling at 30 mph (48 km/h) that is in the Highway Code. Therefore if the driver of the car braked when the train first came into view, he would have been unlikely to be able to stop in time to avoid a collision. There was no evidence of any tyre skid marks to suggest that the car driver had attempted any sudden emergency braking.

12 There was no evidence that the car driver was distracted by something within the vehicle (such as the use of a mobile phone), as he was driving towards the crossing.

The train driver, the train and its operation

13 The RAIB has concluded that the train driver could have done nothing more to reduce the consequences of the accident and there were no factors concerning the performance of the train that contributed to the accident.

14 There were no issues concerning the competence and fitness of the train driver to drive. After the accident, the British Transport Police tested him for the presence of alcohol and the results were negative.

15 The train's data recorder indicated that the train was travelling at 47.5 mph (76.4 km/h) when it struck the car (paragraph 32). This is less than the required crossing speed (50 mph (80 km/h)) for the crossing (paragraph 14).

16 A car approaching from the train's right-hand side at 30 mph (13.33 m/s), would first be visible from the train's cab when the train was about 30 metres from the crossing. However, the train driver stated that he did not see the car before the collision, probably because his view was obscured by the gangway, and therefore did not apply the train's brake until after the collision occurred. Even if he had been able to see the car when it first became visible, he would only have had 1.5 seconds to react, and it is unlikely that he would have processed the information and applied the brakes in this time.

The crossing's operation

17 The crossing was operating as it was designed to do when the accident occurred.

18 No data recorder was fitted at the crossing to record its operation.

19 Witnesses in a vehicle approaching the north side of the crossing confirmed that the road traffic light signals on that side were operating as the train approached (paragraph 35).

20 Following the accident, the crossing was tested in accordance with Network Rail's standard procedures. The extent of this testing was verified by and then witnessed by RAIB inspectors. No faults were found with the operation of the crossing (paragraphs 44 to 46).

Crossing signs

21 The RAIB has concluded that the positioning of the advance warning signs on the southerly approach to the level crossing was reasonable.

22 The location of warning signs such as the level crossing ahead warning sign and 'STOP when lights show' warning sign is specified in Chapter 4 of the Traffic Signs Manual published by the Department for Transport[24]. It contains a table of distances, for different approach speeds by 85% of private cars, to the hazard ahead. For approach speeds greater than 50 mph (80 km/h) the signs should be located between 180 and 245 metres from the crossing road traffic light signals. For approach speeds between 30 mph (48 km/h) and 40 mph (64 km/h), the signs should be located between 45 and 110 metres from the road traffic light signals.

23 At Halkirk crossing, the signs, highlighted by a reflective yellow backboard, were 106 metres from the road traffic light signals (paragraph 26) (the information on them could be read by the RAIB inspectors on site from a position 72 metres from the signs). A road vehicle driver approaching the level crossing with normal eyesight should therefore be aware that there is a level crossing ahead some 178 metres from the road traffic light signals. This compares with the normal braking distance (from the Highway Code) for a car travelling at 60 mph (96 km/h) of 73 metres.

24 At this distance, the road traffic light signals when operating are clearly visible along the straight approach of the road and this visibility distance exceeds the 73 metres typical stopping distance for a vehicle travelling at 60 mph (97 km/h) that is in the Highway Code.

25 The signs on the southerly approach to Halkirk crossing are located at a distance applicable to the 30 to 40 mph (48 to 64 km/h) speed band in the ORR's guidance on level crossings and in Chapter 4 of the Traffic Signs Manual (paragraph 26) whereas for an approach speed of 60 mph (96 km/h) the guidance states the signs should be 180 to 245 metres from the crossing. However, road traffic should be slowing down for the 30 mph signs before the crossing and the advance warning signs are located at a place where they are clearly visible to approaching road traffic. The positioning of the advance warning signs should allow sufficient braking distance for vehicles to stop at the crossing.

Crossing inspections

26 The RAIB has concluded that the system of routine inspections of the level crossing by Network Rail was carried out in accordance with its procedures, although the priority assigned to the remedial work required to the backboards was for rectification within six months and this was repeated at successive inspections.

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[24] Fourth impression with amendments dated 2004, ISBN 0115524110.

27 Network Rail staff inspected Halkirk level crossing in accordance with its standard NR/L2/SIG/19608 'Level Crossing Infrastructure: Maintenance and Inspection'. This required inspections to be carried out at seven weekly intervals or less. Inspections during 2009 and before the accident were carried out on the following dates:

- 19 January 2009
- 5 March 2009
- 22 April 2009
- 2 June 2009
- 21 July 2009
- 31 August 2009

28 Staff carrying out the inspections used a checklist from standard NR/L2/SIG/19608 contained in a handheld computer. This also allowed a limited amount of free text entry. When completed, staff docked the handheld computer and the information was uploaded to the *Ellipse database.* By this means, the completion of an inspection was logged in Ellipse and the system planned when the next inspection was due to be carried out.

29 One of the checks required by the standard was of the road traffic light signals:

- the nearside road traffic light signal should be unobstructed and aligned approximately 1.5 metres above the centre of the road at 100 metres on the approach to the crossing stop line; and
- the offside road traffic light signal should be unobstructed and aligned approximately 1.5 metres above the centre of the road at 50 metres on the approach to the crossing stop line.

30 The above requirements were modified by Technical Instruction TI 136 'Alignment of Level Crossing Road Traffic Light Signals (Road traffic light signals)' issued in April 2009. This required that the alignment be checked from the nearside edge of the roadway or footpath. The change was made to prevent staff carrying out the checks having to stand in the road.

31 Any defects found during an inspection that could not be corrected at the time were required to be logged on a work arising form and sent to the relevant department for the work to be carried out.

Crossing maintenance

32 The evidence indicates that the requirements to maintain the level crossing were followed and that there were no deficiencies in the maintenance of it that were related to the causation of the accident with the exception of the backboards.

33 The level crossing was maintained in accordance with the requirements of Network Rail company standard NR/L3/SIG/10663 'Signal Maintenance Specifications'. Standard NR/L2/SIG/10661 'Signal Maintenance Task Intervals'. specified that the maintenance was undertaken at three monthly intervals with additional maintenance being required annually.

34 Technicians recorded completed maintenance in hand held computers which were then docked to the Ellipse system. This then programmed the date of the next maintenance visit.

35 Records show that maintenance was carried out at Halkirk crossing on the following dates during the 12 months before the accident:

- 27 October 2008
- 19 January 2009
- 14 April 2009
- 12 July 2009
- 25 August 2009 (this was the date when annual maintenance was carried out)
- 28 September 2009

36 Apart from the level crossing annual test required by NR/SMS/LC10, records were not available to confirm that the following maintenance specifications had been carried out because they had not been loaded into Ellipse as Maintenance Schedule Tasks:

- NR/SMS/LC10 ‘Level Crossing Operational Sequence’
- NR/SMS/LC11 ‘Road Lights & Audible Warnings’

NR/SMS/LC11 included the requirement to check the alignment of the road traffic light signals.

37 There was no work arising following the maintenance visit on 28 September 2009 and the only work arising forms that were outstanding at the time of the accident were those that had been raised following inspections of the crossing. These included the condition of road traffic light signal backboards.

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