RAIB

Rail Accident Investigation Branch

Rail Accident Report

Collision between a train and a car at Beech Hill level crossing, near Finningley
4 December 2012

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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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v2	27/09/13	13, Appendix B	Minor technical correction and definition added

Collision between a train and a car at Beech Hill level crossing, near Finningley, 4 December 2012

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Summary

At 12:31 hrs on Tuesday 4 December 2012 a collision occurred between a passenger train and a car at Beech Hill automatic half barrier (AHB) level crossing near Finningley, on the line between Gainsborough and Doncaster. One of the occupants of the car, a young child, was seriously injured in the collision and later died in hospital.

The train involved was operated by East Midlands Trains. It consisted of a single carriage unit and was travelling at 60 mph (96 km/h) at the time of the collision. None of the 20 passengers and two crew members on the train was injured in the accident. Equipment beneath the train was damaged in the collision leading to the spillage of diesel fuel from the train's fuel tank, but there was no fire.

The level crossing was owned and maintained by Network Rail and was fitted with a data logger which showed that the crossing was operating normally at the time of the accident, with the barriers down as the car approached. The car driver stated that she did not see that the road traffic light signals (known as wig-wags) were flashing as she approached and only noticed the lights and barriers when she was very close to the crossing. The weather was sunny at the time of the collision but there had been rain showers earlier and the road surface was wet, leading to glare from the low winter sun.

The RAIB took the wig-wag units and arranged for testing in an optical laboratory. It was found that they were fitted with 36 W lamps and an obsolete design of red lens unit. Their light output was measured to be well below the specification for lights of this type. Network Rail had no plans in place to replace the light units with brighter ones and had no process to identify that such replacement was necessary.

The RAIB has made four recommendations as follows:

- infrastructure managers to determine which level crossings are fitted with 36 W lamps and draw up plans for their replacement with LED units;
- infrastructure managers to devise a method of assessing the risk of a bright background and glare preventing wig-wag signals from being seen and propose means of mitigating this;
- infrastructure managers to introduce a new 'brighter' type of LED wig-wag for use at sites where sunlight glare has been identified as a problem; and
- infrastructure managers to enhance the inspection and maintenance process for wig-wag lamps.

Introduction

Preface

1 The purpose of a Rail Accident Investigation Branch (RAIB) investigation is to improve railway safety by preventing future railway accidents or by mitigating their consequences. It is not the purpose of such an investigation to establish blame or liability.

2 Accordingly, it is inappropriate that RAIB reports should be used to assign fault or blame, or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

3 The RAIB's investigation (including its scope, methods, conclusions and recommendations) is independent of the inquest, and all other investigations, including those carried out by the safety authority, police or railway industry.

Key definitions

4 All dimensions in this report are given in metric units, except speeds and distances which are given in imperial units in accordance with normal Network Rail and UK road practice. Where appropriate, the equivalent metric value is also given.

5 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

6 At 12:31 hrs on Tuesday 4 December 2012, train reporting number 2K36, the 11:54 hrs passenger train service from Lincoln to Doncaster, struck a car on Beech Hill automatic half barrier[1] (AHB) crossing between Gainsborough and Doncaster.

7 The impact caused extensive damage to the car. One of the occupants, a young child, was seriously injured in the collision and later died in hospital. The car driver was also taken to hospital for treatment to injuries sustained in the accident.

8 Nobody on the train was injured.

9 The train was not derailed but sustained damage to some of the equipment mounted under the floor. The fuel tank was punctured and most of the diesel fuel leaked out onto the track, but there was no fire.

10 The railway was closed until 06:11 hrs on 6 December for recovery of the damaged train and repair of the crossing.

Background

The crossing

11 Beech Hill AHB crossing is located between Beckingham and Finningley on the line between Gainsborough Trent junction and Doncaster (figure 1). It is located approximately 11 miles (17.6 km) from Gainsborough and 6½ miles (10.4 km) from Doncaster. The railway is double track and is straight. Springs Road is a minor road which links the B1396 with the A614 and is straight for some distance either side of the crossing. The maximum permitted speed for trains is 60 mph (96 km/h). The national speed limit applies on the road (60 mph (96 km/h)).

12 The line is signalled under the *track circuit block* system from Doncaster signalling control centre.

13 The crossing is equipped with warning signs, *wig-wags*, half barriers and telephones which connect to the *gate box* at Finningley level crossing. Figure 2 shows the approach to the crossing in the direction that the car was travelling. Each half barrier is fitted with two *boom lamps* which are small red lamps that are visible from both sides of the crossing. These lamps are designed to make the barriers more visible at night. The crossing also has a bell which starts ringing when the amber light of the wag-wags become lit, to warn pedestrians. The bell is intended only for pedestrians and is unlikely to be heard from an approaching car. The crossing is automatically activated by approaching trains and indications of the status of the crossing equipment are displayed in Finningley level crossing signal box. The status indications show only whether the barriers have failed and whether the power supply to the crossing is on (these did not indicate a fault prior to the accident).

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

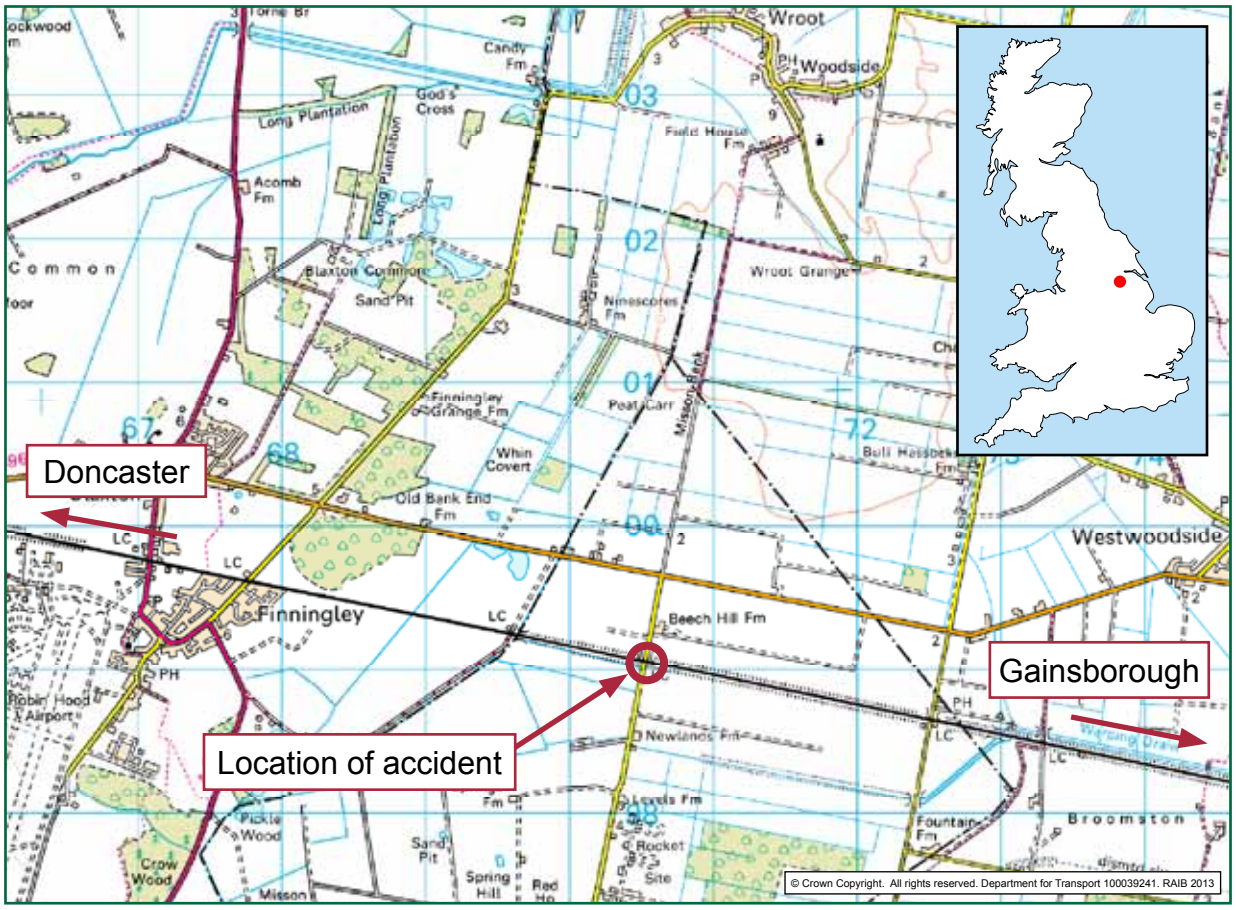

Figure 1: Extract from Ordnance Survey map showing location of the accident

14 The crossing is fitted with a data logger which showed that it was working correctly prior to the accident. Network Rail tested the crossing equipment, including the data logger, under RAIB supervision after the accident and no faults were found with the crossing equipment or the data logger.

15 The crossing was originally equipped with manually operated gates but was converted to an AHB crossing in 1966. This conversion was authorised by a *level crossing order* issued by the Railway Inspectorate (RI)[2] on behalf of the Secretary of State under section 66 of the British Transport Commission Act (1957). Various modifications were made to the crossing between 1969 and 1974. These improvements included longer warning times of approaching trains (increased to 37 seconds), the addition of an amber lamp to the wig-wags, yellow 'box junction' markings on the road, *whistle boards* on the railway approaches, to prompt train drivers to give audible warning of their approach, and flashing neon signs with the wording 'another train coming'. These modifications were authorised by level crossing order amendments numbered 1 to 4, issued by the RI.

16 Further alterations to the crossing were made in 1976 and 1981, when level crossing order amendments no. 5 and 6 were made. These involved moving the whistle boards and moving the supervising signal box to Finningley.

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

Figure 2: Road approach to Beech Hill AHB crossing

17 British Rail asked the RI for a further level crossing order amendment, no. 7, in May 1981. This was intended to bring the crossing into line with current standards for AHB crossings and included the removal of the neon 'another train coming' signs, reduction in the number of telephones and removal of whistle boards. This order was not issued and the RAIB has been unable to determine the reason for this.

18 Despite the non-issue of level crossing order amendment no. 7, some of the changes in it were made in the years between 1981 and 2006. The whistle boards and telephones remained at the crossing but played no part in the cause of this accident (the whistle boards are intended only to warn pedestrians of an approaching train).

19 In October 2006 Network Rail asked the Office of Rail Regulation (ORR – the successor organisation to HMRI) for a level crossing order amendment to remove the neon 'another train coming' signs from Beech Hill crossing and a number of other crossings in the area. ORR issued this amendment as the 'Network Rail (General Amendment LNE) Order' in March 2007, coming into force on 2 April 2007. The date when the signs were removed was not recorded and they were not present at the time of the accident.

The car driver

20 The driver of the car was 67 years old and had been a driver for 50 years. She lived locally and made the journey that she was making on the day of the accident twice a week, though not all journeys were via Beech Hill crossing. She stated that she was aware that there was a level crossing at Beech Hill and that she understood the meaning of the wig-wag signals at the crossing.

21 The car driver needed to wear glasses when driving and her last eyesight test was in March 2011 when she was prescribed new glasses. She stated that she was wearing these glasses at the time of the accident.

22 Information provided to the RAIB indicates that the car driver had suffered from a medical condition which the NHS website says can cause symptoms such as visual disturbance and numbness or weakness in the arms and legs. This had occurred on 2 occasions, the most recent being 9 ½ years earlier. She had received treatment for this condition and she stated that she had experienced no further occurrences since then.

The accident

23 The train approached the crossing and operated the *track circuit* and *treadles* which initiated the level crossing closure sequence. This caused the amber lights on the road traffic light signals to become lit at 12:30:42.7 hrs, as recorded by the data logger.

24 Five seconds later (at 12:30:47 hrs) the red lights became lit. After another 7.8 seconds (at 12:30:55 hrs) the barriers started to descend. The barriers were proved to be fully lowered by the detector circuits at 12:31:03.16 hrs, 7.6 seconds after they started to lower and 20.5 seconds after the amber lights first lit. The timings of the operation of the crossing complied with the timings specified in the crossing order but some were longer than the timings given in the ORR guidance document '*Level Crossings: A guide for managers, designers and operators', Railway Safety Publication 7, December 2011'.* However, the length of these timings is unlikely to have been a factor in the cause of the accident.

25 The car approached the crossing travelling in a southerly direction, directly towards the sun which was low in the sky. The car driver stated that she did not see that the wig-wags were flashing as she approached and only noticed the lights and barriers when she was very close to the crossing.

26 The car collided with the level crossing barrier on the north side of the crossing causing the 'barriers down' detection to be lost at 12:31:19.98 hrs (37 seconds after the amber lights became lit). At this time the train was approaching the crossing travelling at 60 mph (96 km/h), according to the train's *on train monitoring recorder*. The crossing data logger recorded that the train was at a point 16.5 metres from the edge of the roadway at 12:31:20.11 hrs. The train and car collided 0.6 seconds later.

27 Analysis of the pictures from the forward facing CCTV on the train showed that the car appeared to be braking as it ran onto the crossing. This was confirmed by the driver of a car that was following the car involved in the collision, who stated that the brake lights were on. She stated that she had seen that the wig-wags were lit as soon as she turned off the main road, which is 600 metres from the crossing, and thought that the car in front was going to stop at the crossing.

28 The train driver could not see the car approaching the level crossing as his view of the road approach was obstructed by buildings and vegetation. He was looking towards a signal further up the line and was unaware of the car's encroachment onto the crossing as it was below his field of view. After the collision he went to apply the brake and found that it had already been applied automatically as a result of damage sustained by the train in the collision.

29 The train was not derailed and came to rest 479 metres from the crossing.

Figure 3: The train involved

Events following the accident

30 The train driver saw that a locomotive was approaching on the other line and displayed a red flag to stop it before it reached the crossing, as he was required to do by Rule Book module M 'Mishaps, incidents and extreme weather'.

31 The train conductor came to the driver's cab to report that there was fuel leaking and what appeared to be smoke rising from beneath the train. The driver and conductor decided to evacuate the passengers as quickly as possible as they believed that there was a risk of a fire.

32 The driver stated that he saw the locomotive on the other line had stopped before reaching the crossing, so he knew there would be no further train movements on either line, and started the evacuation immediately. He then used the emergency button on the *NRN radio* to contact Network Rail control and report the collision.

33 The passengers were taken a sufficient distance away from the train so that if a fire started they would not be put at risk. When Network Rail response staff arrived the passengers were led to the next crossing along the line where they were met by road transport. The RAIB commends the prompt actions of the train crew in stopping the approaching locomotive and safely evacuating the passengers.

34 The driver of the car was assisted from the wreckage by the resident of an adjacent house and a road vehicle driver who was travelling in the opposite direction over the crossing. They also carried the child from the car to the house and called the emergency services. The Nottinghamshire police were the first to arrive, at 12:43 hrs and the first paramedic arrived at 12:54 hrs.

35 The car driver was taken to hospital by ambulance and the child passenger was taken to a specialist unit by air ambulance. Unfortunately, she died from her injuries that night.

Identification of the immediate cause[3]

36 **The car went onto the crossing while the red wig-wag road traffic light signals were flashing, the barriers were down and a train was approaching.**

37 The data logger fitted to the crossing (paragraph 14) recorded that the barriers had been down for over 16 seconds before the 'barriers down' detection contact was broken by the car striking the barrier (paragraph 26). The detection of the barrier position is achieved by means of electrical contacts attached to the barrier mechanism which detect its position.

Identification of causal factors[4]

Environmental conditions

38 **The lighting conditions at the time of the accident made it difficult for road users approaching from the north side of the crossing to see the wig-wags and barriers.**

39 The sun was bright and low in the sky, and at the time of the accident was shining from behind the wig-wags towards the approaching car. The road surface was wet from rain earlier in the day and this led to *glare* from the sun reflecting back off the road. This had the effect of making the road surface up to, and beyond, the crossing appear shiny and apparently clear to drive over. Figure 6 shows this view in similar conditions the day after the accident.

40 The crossing barrier was aligned with trees on the horizon beyond the crossing. This provided a dark band which was directly behind the barriers in the field of view of the car driver, the relevance of which is explained in paragraph 60.

Visibility of the level crossing equipment

41 **The visibility of the level crossing wig-wag lights and barriers against the background was poor. This was a causal factor.**

42 After the accident, Network Rail attached a replacement crossing boom on the side from which the car approached and connected the red boom lights to their electrical supply. The weather conditions on the day after the accident were similar to the day of the accident, with bright sun and a wet road surface. The road approach to the crossing was photographed at the same time of day as the accident. Figure 4a is a photograph taken from a point in the road 62 metres back from the crossing and figure 4b is taken from 45 metres back in conditions similar to those at the time of the accident. This is around the point at which a road vehicle driver travelling at the average speed of traffic on this road[5] should have seen the wig-wags and be preparing to stop.

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

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

[5] Network Rail commissioned a traffic survey of the crossing over a nine day period in January 2012 which reported that the 85th percentile speed for road traffic approaching the crossing was 49 mph (78 km/h). The Highway Code states the stopping distance from a speed of 50 mph (80 km/h) is 53 metres.

Figure 4: The approach to the crossing in similar conditions at the same time of day on the day after the accident – (a) shows the view from 62 metres and (b) shows the view from 45 metres away

43 The crossing barrier was down, with the boom lamps lit and the wig-wag lights were flashing when the photographs of the approach were taken. The optical response of the camera may not match that of the human eye, however the photographs match the observations made by the RAIB inspector who was accompanied by several observers from Network Rail. That the crossing was activated was not readily apparent to any of those present when viewing the crossing from a range of distances between 129 metres and 45 metres. The wig-wag lamps became more clearly visible at distances closer to the crossing than 45 metres.

44 The following factors contributed to the poor visibility of the crossing in the prevailing environmental conditions:

- the light output of the red wig-wag units was low and was hard to see against the bright sunlight;
- the light output of the lamps was less than specified and the obsolete lenses further reduced it; and
- the barriers were not conspicuous against the background.

Furthermore, Network Rail does not have a process for checking that wig-wag units meet their specification.

Each of these factors is discussed below.

Wig-wag red light units

45 **The light output from the red wig-wags was low and was hard to see against the bright sunlight.**

46 After making observations of the crossing in similar conditions the day after the accident, the RAIB removed the wig-wag units from the north side of the crossing (the side that the car approached from) and had the red light units tested in the laboratory by an optical specialist.

47 The red light units were fitted with 36 W incandescent lamps[6] and the specification for the light units is British Railways Board (BRB) Specification no. 908 'Colour Light Signal Units (8 Inch) for Road Traffic Signals at Level Crossings', dated March 1969. The manufacturing specification for the lamps themselves was BS 941:1958 'Automobile Filament Lamps'. These specifications together defined the *brightness* (*luminous intensity*) of the *lamp unit* and the light output (*luminous flux*) of the lamp. The equivalent current standard for road traffic light signals is EN 12368 (paragraph 90). This standard specifies a range of performance criteria but does not specify the type of lamp, so does not preclude the use of 36 W incandescent lamps, provided they meet the performance criteria.

48 The brightness (luminous intensity) of the red light units (the unit consists of the lamp, reflector and lens) was specified in BRB specification 908 to be 500 *cd* along the axis of the light unit. When tested, the four red light units from the wig-wag signals on the north side of the crossing had luminous intensities of between 101 cd and 222 cd, well below the minimum specified. RAIB issued *urgent safety advice* to the industry (appendix C) on 16 April 2013 to advise them of this as there were other crossings fitted with the same type of light unit.

49 Research carried out in the context of road vehicle drivers' ability to perceive and respond to traffic signals[7] has found that the important attributes were visual sensitivity, visual acuity and perception of colour. Visual sensitivity refers to the ability of the eye to respond to luminance (brightness) differences and contrast. The research found that the threshold for detection of contrast rises with age and that a driver aged 65 requires the contrast to be 80% higher than a young, ocularly fit, person.

50 The optical specialist determined that the range of *luminance* values in the field of view of a car driver approaching the crossing in the conditions that prevailed at the time of the accident were as given in table 1.

Area	Luminance (*cd/m²*)
Unlit red wig-wag signal	40
Lit red wig-wag signal	3,400
Back board	61
Sky*	600 – 4,000
Wet Road*	500,000 – 2,000,000
Sun disk*	800,000,000

Table 1: Luminance values of areas in car driver's field of view.

* *The values for sky, wet road and sun disk are typical values and are not necessarily specific to Beech Hill crossing at the time of the accident.*

[6] Generally, wig-wags in use on Network Rail infrastructure are fitted with either 36 W incandescent lamps, 50 W halogen lamps or LEDs.

[7] 'Human Factors Considerations in the Selection of a Uniform Protected/Permitted Left-Turn Signal Display', David A. Noyce, Ph.D., P.E., a Paper prepared for Transportation Frontiers for the Next Millennium: 69th Annual Meeting of the Institute of Transportation Engineers, Las Vegas, Nevada, August 1-4, 1999.

51 Identifying that the red wig-wag lights are lit requires the observer to distinguish between the lit red light unit, with a luminance of 3400 cd/m^2, and the back board, with a luminance of 61 cd/m^2, against a background which includes areas with luminance many orders of magnitude higher. The eye adjusts its response to the general luminance level, thus making it very difficult to distinguish between the lit red wig-wag light and the back board.

52 The light output of an incandescent lamp takes a finite time to reach full brilliance. As each wig-wag light flashes on and off, the time that the lamp is at full brilliance is less than the 'on' time of the lamp. The light output of one of the lamps was measured over time while it was flashing and the lamp was found to be at full brilliance for only 350 ms of the 500 ms flash period. This would further reduce the conspicuity of the wig-wag signals.

53 The light units are designed to accept only one type of lamp and if a brighter lamp was needed, the unit would have to be changed for one of a different design. Modern wig-wag units do not use incandescent lamps and are fitted with LED lamps. These are more efficient than incandescent lamps and reach full light output almost instantly. LED wig-wag lamps are discussed in paragraphs 89 to 92.

Wig-wag red light unit lamps and lenses

54 **The light output of the 36 W lamps in the wig-wag red light units was less than specified by BRB specification 908 and the output of the light units was further reduced by the red lenses that were fitted. These were of an obsolete design that also did not meet the specification.**

55 The lamps (light bulbs) from the wig-wag red light units were tested for their total light output in all directions (luminous flux). The specification referred to by BR908 (BS 941:1958) stated that the luminous flux of the lamp should be at least 486 *lumens*. The lamps removed from the light units at Beech Hill were found to have luminous flux values of between 249 lumens (right-hand lamp in the offside wig-wag unit) and 396 lumens (left-hand lamp in the nearside wig-wag unit).

56 The testing of the wig-wag red light units (paragraph 46) included measuring the colour of the emitted light. The colour was found to lie outside the range allowed by the BRB 908 specification, being too far into the deep red area. There is a limit on the depth of the red colour as people with a certain colour vision deficiency have a reduced sensitivity to deep red colours. The car driver's optician did not indicate she suffered from this deficiency.

57 The lenses fitted to the wig-wag light units were marked with a raised motif of an eagle and the word 'Bliss' at their centre (figure 5). The markings are the trademark of the company which manufactured them, E.W.Bliss Eagle Signal Company. The BRB 908 specification requires that the external surface of the lens is completely smooth, so the lenses did not comply with the specification in this respect, though it is possible that these lenses might predate the specification. The effect of the raised motif on the performance of the lens was not assessed. The inside surface of a wig-wag lens is moulded with many small indentations to focus the light. The quality of finish of these indentations on the lenses from Beech Hill was not as high as on modern lenses and this may have impaired the performance of the lens.

Figure 5: Close up of 'Bliss' lens fitted to one of the wig-wag units at the north side of the crossing

58 The effect of the lens on the light output of the red light units was assessed in the laboratory by replacing the 'Bliss' lens with the modern equivalent, taken from a new 50 W halogen wig-wag unit. The right-hand wig-wag lamp from the unit on the nearside of the road was selected for testing. The diameter of the 'Bliss' lens is less than the diameter of the modern lens and a temporary clamp arrangement was used to hold the new lens in front of the lamp. The luminous intensity of the combined lamp and lens was improved from 110 cd to 178 cd but still did not reach the 500 cd level required by the BRB 908 specification.

Level crossing barriers

59 **The crossing barrier was not conspicuous against the background. This was exacerbated by the brightness of the background and glare from reflection off the wet road.**

60 The railway is raised above the general ground level at Beech Hill and the road is also raised on the approach to the crossing from the north. The combination of the low horizon and raised viewpoint approaching the crossing from the north side made the barrier difficult to discern against the dark background near the horizon in the conditions that prevailed at the time of the accident (figure 6). An electricity pole on the left of the road before the crossing may also have given the appearance of a raised barrier.

Figure 6: The approach to the crossing as seen from a point 45 metres back from it

61 RSSB[8] has commissioned research into level crossing signage, including the human factors that influence perception of the crossing. The final report of the first phase of this project was published in July 2011 as report T756 'Research into signs and signals at level crossings'. A further phase of this project aims to develop and test suggestions for improvements to crossing signage and signals and is due to be completed in 2014. This work is planned to include investigation into improvements to the conspicuity of the crossing booms. The booms fitted to crossings where the barriers close off the whole carriageway are fitted with skirts which hang vertically beneath the boom and obstruct the space between the boom and the road surface. Inclusion of these skirts on the booms at Beech Hill might have improved their conspicuity in conditions like those that prevailed on the day of the accident as the skirts may block glare from the road surface on and beyond the crossing. However, there may also be other novel and more effective ways of improving their conspicuity.

Network Rail's level crossing inspection process

62 **Network Rail does not have a process for checking that existing wig-wag lamps and lenses continued to meet their specification.**

63 Network Rail has several processes in place for periodic inspection, maintenance and risk assessment of AHB crossings and the ones that prevailed at the time of the accident were:

(i) Maintenance staff carry out inspections every seven weeks following a process specified in Network Rail's standard NR/L2/SIG/19608 'Level Crossing Infrastructure: Inspection and Maintenance'.

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

(ii) Signalling staff carry out inspection and maintenance according to Network Rail's standard NR/SP/SIG/10660 'Implementation of Signalling Maintenance Specifications', process RT/SMS/LC10 'Level Crossing Inspection and Maintenance'. This specifies two levels of inspection and maintenance, one to be done every three months and one annually.

(iii) Operations staff carry out a risk assessment of the crossing every 18 months, which includes a site visit to gather data on crossing usage and other factors. These visits are carried out to provide input to Network Rail's All Level Crossings Risk Model (ALCRM) (paragraph 67) and are mandated by Network Rail standard NR/SP/OPS/100 'Provision, Risk Assessment and Review of Level Crossings'.

Network Rail has recently appointed level crossing managers who now undertake the inspection and risk assessment described in (i) and (ii).

64 Network Rail's most recent seven-weekly inspection was carried out on 22 October 2012. This inspection included checking the alignment and visibility of the wig-wags. The inspector noted that the alignment and visibility of the wig-wag lights on the nearside of the road at the north side of the crossing was unsatisfactory and that this required fixing within 7 weeks (ie before the next inspection). Network Rail's work planning system recorded that this defect was remedied on 15 November.

65 The last annual maintenance and inspection visit prior to the accident was conducted on 11 July 2012 and the inspector noted only one non-conformance requiring corrective action (this stated that the site plan was out of date, rather than that the crossing did not comply with the plan). The list of checks to be carried out at the annual service included checking the alignment of the lights but not their level of light output. The list also included checking that '*the signal lenses are undamaged, clean and correctly orientated*'. The inspector noted that he had cleaned the lenses and that they satisfied this check. The list of checks did not include checking that the lenses met their specification. The lenses fitted at this crossing did not meet this requirement in that they had a raised manufacturer's name and logo at their centre (figure 5).

66 The last three-monthly inspection was made on 6 November 2012 and no defects were identified.

67 The last risk assessment prior to the accident was undertaken on 30 January 2012. The risk assessment was done using ALCRM. This is a computer-based application used by Network Rail to assist in the risk management of level crossings. It takes the features and usage of the crossing into account to calculate a risk score. This is made up of two parts, a collective risk and an individual risk. The collective risk is an estimate of the total risk generated by the crossing for all road users and the occupants of trains, whereas the individual risk is an estimate of the risk of death for a notional regular crossing user. The risk score from ALCRM is intended to support and inform an assessor in considering the risk mitigation options for the crossing.

68 The risk assessment made on 30 January 2012 assessed the risk as F5. This represents a collective risk of 5 on a scale from 1 (highest risk) to 13 (lowest). The individual risk, F, is in 6th place on a scale from A to M. Network Rail standard NR/SP/OPS/100 states that ALCRM should be supported by expert judgement or additional risk assessment processes where required. There is no evidence that additional risk assessment was done during the January 2012 assessment and no evidence that the assessor referred to an options study done in July 2011 (paragraph 69).

69 In July 2011, the Network Rail operations risk advisor carried out a study of the options for improving the crossing. This was part of a programme to prepare an options document for every level crossing on the London North Eastern Route. Two options were selected for further consideration: upgrade of the crossing to full barriers (MCB OD or CCTV); and fitting extended hoods to the wig-wag lights to overcome problems of sun glare at certain times of day. The action recorded against the full barriers option stated 'To review' and the action recorded against the hoods[9] option stated 'Preferred option would be LED RTLS[10]'. Both options had 'work bank' entered in the timescale column. The option of converting the crossing to an MCB crossing was considered as part of a Network Rail upgrading project for this line but was not pursued as the crossing had a low usage, compared to other AHB crossings on the line, and Network Rail judged that upgrading it to modern AHB standards was the best option. Conversion of the crossing to an MCB crossing would involve the installation of full barriers with skirts. This would not improve the visibility of the wig-wag signals in sun glare conditions, but the presence of the skirts across the full width of the road might improve visibility of the barriers. The installation of LED wig-wags was not entered into the work bank and Network Rail has been unable to explain to the RAIB why this was not done.

Network Rail's level crossing management process

Effect of sunlight

70 **Network Rail's level crossing management process does not fully recognise the effect of sunlight on the visibility of the crossing equipment. This was a causal factor.**

71 Network Rail's level crossing risk assessment process includes a site visit to gather information for the assessment. During site visits in 2005 and 2006 the inspector noted that low sun was a problem at this crossing. The 2005 inspection recorded that extended hoods were not fitted to the wig-wags. Extended hoods provide some protection from the risk of sunlight falling on the lens 'washing out' the red light making it hard to discern on the wig-wags which face towards the sun. They do not provide mitigation for the problem of bright sunlight shining from behind the wig-wag units, as was the case on the north side of Beech Hill crossing. Extended hoods were also recommended in the 2006 inspection report but were not fitted and were not mentioned in subsequent inspection reports, though the optioneering study done in July 2011 (paragraph 69) recognised that sun glare could be a problem.

[9] Extended hoods on the wig-wag lights would not have any effect on their visibility when viewed with the sun behind them, as here.

[10] RTLS is an abbreviation for road traffic light signals, commonly known as wig-wags.

72 The inspector who made the 2007 inspection used a revised data gathering form on which the question '*is low sun a problem?'* had been replaced by the question '*Is the horizon looking across the crossing (tick the one most applicable)*'. The options for the answer to this question were '*Low horizon – the sun could be below the lights and signs when approaching the crossing'* and '*The horizon is high – hilly or mountainous terrain, low sun blocked, or horizon not an issue'*. Both answer boxes were marked with a cross on the 2007 report form but the 'low horizon' one was struck out. Subsequent inspections in the years 2008 to 2012 ticked the 'high horizon' reply to this question. The landscape around Beech Hill crossing is flat fenland and is not mountainous or hilly.

73 The ALCRM user guide provides guidance to inspectors gathering data for input to the ALCRM. The guidance deals with sunlight under the heading 'Orientation of Road/Path'. It states that if the road is aligned east-west or if the crossing could be affected by sunlight, the inspector must decide whether the horizon is low or high. This implies that, for a crossing that is not aligned east-west, the low horizon question need only be answered if the inspector considers that the crossing could be affected by sunlight.

74 The data collection forms used when gathering data for an ALCRM assessment are given in Network Rail's Operations Manual Procedure 5-23. Issue 1 of this procedure stated that the low horizon question need only be answered '*If the crossing orientation is east west (90 to 270 degrees)'.* This statement was replaced by '*Consider whether sun glare can be an issue at this crossing at any time of the year'* in issue 2 of the procedure, dated March 2010, which has the effect of making it mandatory to consider the level of the horizon. However, no guidance is given on how to assess whether sun glare can be an issue.

75 The data gathered on the site visits is input to the ALCRM which then calculates the level of risk. The result sheets from the risk assessment calculations at Beech Hill from 2001 to date all have the 'high horizon/sunlight not a problem' option (or its equivalent) ticked. As a consequence, at no point did the calculation of risk undertaken by the ALCRM take this into account.

76 The RAIB investigated the effect of ticking the 'low horizon/sunlight a problem' box in the ALCRM by asking Network Rail to revise the ALCRM data for Beech Hill crossing to include a tick in the 'low horizon' box. The effect was to raise the individual risk score by one level. The collective risk score was unchanged. Since it is the collective risk score which is used to assess the cost effectiveness of mitigation measures, it appears that the identification of a problem with sunlight may have a limited impact on the consideration of options for improvement.

77 The ALCRM data includes the direction of the road and railway at the crossing expressed as compass bearings (degrees from North). This data is not, however, used in the assessment and is only for the information of the reader. Network Rail and RSSB (who maintain the ALCRM) have considered whether to extend ALCRM to use this information to predict sun risk at a crossing, but have decided not to implement this change yet.

78 The 'sunlight a problem' box is regarded as 'fixed' information in ALCRM, in that it is information that is input once and is unlikely to change. The data held in ALCRM shows that approximately half of the total population of crossings have this box ticked.

79 The RSSB level crossing risk management toolkit provides advice to the industry on level crossing risks and their mitigations. This identifies a number of human factor issues (HFI) linked to sunlight. These include:

- distraction or loss of visibility due to the effect of the sun shining through trees producing a strobing effect (HFI 23);
- direct glare temporarily blinding motorists (HFI 23);
- poor conspicuity of flashing lights due to glare and/or limited light output (HFI 22); and
- sunlight shining directly on light units can appear to 'wash-out' the light emitted by the unit (HF119)[11].

80 The mitigations suggested include the following:

- improve sighting of wig-wags by removal of foliage and obstructions (HFI 22 and 23);
- install audible alarms (HFI 23);
- fit LED wig-wags (HFI 22 and 23);
- optimise position of the warning lights (HFI 22);
- provision of red and white chequered edges to wig-wag back boards (HFI 22); and
- provision of sun hoods on wig-wags (HFI 22 and 119).

81 Of all the above, the most appropriate mitigation for bright sunlight at Beech Hill is the installation of LED lights[12].

82 The study of options for improving the crossing in July 2011 recommended installation of LED wig-wags (paragraph 69).

Identification of underlying factors

Replacement of lamps

83 **The lamps fitted to the wig-wag signals were of an obsolete design and Network Rail had no plans to replace them. This was an underlying factor.**

84 The lamps fitted to the wig-wag units were 36 W incandescent type (paragraph 47). The output from this type of lamp has been recognised as being poor for many years and the Stott report[13] on the safety of automatic open crossings published in 1987 noted that the light output of the 36 W wig-wag signals was about half that of contemporary road traffic lights.

[11] This 'human factors issue' was added to the level crossing risk management tool kit in March 2010.

[12] The road approach to the crossing at Beech Hill was not obstructed by foliage or other obstructions and the close proximity of a house to the crossing made installation of an audible alarm impractical.

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

85 Following an accident at an automatic open crossing at Wraysholme in Cumbria in 2008 (paragraph 110) the RAIB recommended that Network Rail should revise its method of inspection of automatic level crossings so that it identified road traffic signals that are difficult to discern because of the effect of sunlight, lamp unit performance and alignment and draw up a programme to improve them.

86 Network Rail drew up a programme to replace all 36 W wig-wags at automatic open crossings and a number (subsequently determined to be 50) of AHB crossings and submitted this to the ORR. The ORR informed the RAIB, in August 2010, that it considered that Network Rail had implemented this recommendation.

87 The selection of which AHB crossings to include in Network Rail's programme was made based on the data in the ALCRM on road signal conspicuity. Beech Hill crossing's ALCRM assessment did not record that road signal conspicuity was a problem and so it was not included in this programme.

88 At the time of the accident, Network Rail had no plans to generally replace 36 W lamps in wig-wag signals.

Observations

Specification for LED wig-wag lamps

89 **The brightness (luminous intensity) of LED wig-wag units is at the bottom of the range specified for road traffic lights in the European standard. There is no mechanism to ensure that the light output of wig-wag light units remains comparable to that of traffic light signals used elsewhere on roads.**

90 The current specification for road traffic light signals is European Standard EN12368:2006 '*Traffic control equipment – signal heads*', though the version current at the time of product acceptance of the LED wig-wag units was EN12368:2000. The luminous intensity classification (paragraph 91) is unchanged between the two versions of the standard. This classifies light units according to a range of parameters, including the environment in which they are to be used, the luminous intensity required and the distribution of luminous intensity.

91 Luminous intensity is classified into three performance levels, each specified as a band of intensities. These range from performance level 1/1 (minimum luminous intensity 100 cd, maximum 400 cd) to level 3/2 (minimum intensity 400 cd, maximum 2500 cd). The Traffic Signs Regulations and General Directions 2002 specify that road traffic signals should be to performance level 3/2. Prior to publication of this document the Highways Agency published '*Specification for Road Traffic Signals, TR2206A'* , which contained the same requirement. The LED units used in wig-wag signals are performance level 3/2. Whilst this is the highest performance level, the standard allows a wide range of outputs from 400 cd to 2500 cd. The manufacturer of the LED units tests them before despatch from the factory and two of the units that were installed at Beech Hill after the accident had outputs of 567 cd and 584 cd.

92 In situations where the background to the wig-wags is bright, as at Beech Hill, it is necessary to use lamps that are sufficiently bright to provide adequate contrast with the background (paragraph 49). The existing design of LED unit has a minimum luminous intensity of 400 cd, which is the highest minimum brightness that can be specified in EN12368. If a brighter LED unit was required at a site where sunlight glare is a problem, it would be necessary to specify a minimum intensity different to that in EN12368.

93 The brightness of LED lamps declines over time and, if a constant brightness is required, it is necessary to measure the brightness periodically and replace the lamps when they become too dim. Network Rail has a process in place to do this for LED lamps used in railway signals. LED lamps used in wig-wag signals could, in principle, be subject to a similar maintenance regime, though they are expected to have a much longer service life than railway signals as they are lit for only a very small proportion of the time.

Design of the road traffic light signals

94 **The wig-wag signals used at level crossings only warn the road user when a train is approaching. They do not incorporate a positive indication to the road user that the crossing is clear.**

95 The benefit of a clear indication, in the context of the crossing at Beech Hill, is that it would precondition the crossing user to expect to see a signal lit at the crossing and they would be actively looking for it. In harsh glare conditions it would be apparent to the user that the signal is hard to see rather than not lit. The RSSB T756 research project considered changing the design of the traffic light signals at level crossings but concluded that it was not appropriate to pursue further in the second phase of the T756 work as, on balance, there was no clear advantage. The first phase of the T756 project had shown that the existing wig-wags were well understood by British road users and statistical analysis of accident rates at signalled road junctions and automatic level crossings showed little difference in fatality rate.

Other similar incidents

At Beech Hill crossing

96 After the accident at Beech Hill Network Rail received a report from a member of the public that they had seen a train pass over the crossing at 13:10 hrs on 8 December 2012 without the crossing activating until the train was on the crossing. The weather at the time was bright sunshine and the observer was viewing the crossing from the north side.

97 Network Rail sent staff to test the crossing and download the data logger. The crossing data logger showed that the crossing had activated and the barriers were down. No fault was found during the testing. It is most likely that the member of the public did not see the wig-wag lamps and barrier but that both had operated correctly. At this time the crossing was still fitted with 36 W lamps.

98 Network Rail's fault report data for this crossing indicated that there was also an allegation from a member of the public at 13:10 hrs on 9 December 2010 that the crossing failed to operate when a train passed. The direction that the member of the public viewed the crossing from was not recorded but the weather at the time, as recorded at nearby Finningley airport, was bright sunshine after a frosty morning. It is likely that the conditions were very similar to those at the time of the accident on 4 December 2012.

99 Both of these incidents, and an earlier one in February 1999 for which the RAIB has been unable to determine the circumstances, were recorded in Network Rail's fault system as alleged failures of the crossing to operate. The crossing was tested and no fault was found. There is no evidence that anyone considered that the problem might be the visibility of the crossing in the prevailing conditions.

At other crossings

100 A collision occurred at Wraysholme in Cumbria on 3 November 2008 when a train collided with a car on an automatic open crossing (RAIB report 26/2009[14]). Open crossings have no barriers and the road user is entirely reliant on seeing the lit wig-wags to warn that a train is approaching. At the time of the accident the weather was clear with bright sun shining onto the crossing from behind the car driver. The sun was shining directly into the red lenses which made the non-lit lens appear lit. The wig-wags were fitted with 36 W lamps and the paint on the wig-wag back boards was faded. These effects combined to reduce the contrast between the lit red light and the unlit light, making it very difficult to appreciate that the crossing had activated.

101 The RAIB investigation recommended that Network Rail should make changes to the way in which it inspects and assesses automatic crossings where sunlight may make the wig-wags difficult to discern, and then draw up a programme for improvement of crossings that were identified. ORR subsequently reported that Network Rail was implementing a programme to fit LED light units to all Automatic Open Crossings - Locally Monitored (AOCL) crossings and selected high risk AHBs (paragraph 110). Although some substantive actions were taken in response to recommendation 1 of the Wraysholme report (details are given at paragraphs 111 and 113), the RAIB has been unable to find evidence of new initiatives to improve the ability of risk assessors to identify that sunlight may be a problem at an automatic level crossing or to assess the performance of existing light units.

102 A collision occurred at Halkirk in Scotland on 29 September 2009 when a train collided with a car on an automatic open crossing (RAIB report 16/2010[15]). The weather at the time was sunny with the sun shining directly onto the wig-wags from behind the car driver. The wig-wag lights were 50 W halogen units but the back boards were faded and the level of contrast between the lit red light and the unlit light and back board was low. There had been previous incidents at this crossing where road users had not appreciated that the wig-wags were lit and the RAIB made a recommendation to Network Rail that it enhance its risk assessment process to take into account factors other than those prompted by ALCRM input, such as the previous incident history (paragraph 116).

[14] RAIB reports are available at www.raib.gov.uk.

103 The accidents at Wraysholme and Halkirk both involved the sun shining from behind the approaching car driver onto the wig-wag back boards, reducing the contrast between the board and the lit red lamps.

104 At Beech Hill the sun was shining from behind the wig-wags towards the car driver. This was also the case in an incident at an AHB crossing at Cridling Stubbs, near Knottingley in Yorkshire on 27 February 2013, which occurred in similar lighting conditions to the accident at Beech Hill. A car approached the crossing at 17:17 hrs as the sun, which was shining towards the approaching car, was setting behind a low hill which provided a dark background to the barriers. The sun was shining from directly behind the wig-wags and the car driver did not notice that the crossing had activated as they approached. The car ran through the barrier and into the path of an approaching freight train, whose driver applied the emergency brake. The car driver was able to quickly reverse clear of the line and a collision was avoided.

105 The RAIB examined the crossing at Cridling Stubbs and found that the wig-wag units were fitted with 36 W lamps. The wig-wag on the nearside of the road was fitted with the same type of lens ('Bliss') as at Beech Hill. The wig-wag on the off side of the road was fitted with lenses of a different design, but they were not compliant with the 1969 specification as they also had a raised feature on the outer surface of the lens. The ALCRM data had identified that sunlight glare could be a problem at this crossing. The RAIB did not conduct a separate investigation into this incident as the causal factors were similar to this investigation and are dealt with by the recommendations in this report.

Summary of conclusions

Immediate cause

106 The car drove onto the crossing while the wig-wags were flashing, the barriers were down and a train was approaching (**paragraph 36**).

Causal factors

107 The following causal factors were identified:

a. The visibility of the wig-wags and barriers was poor (**paragraph 41, Recommendations 1 and 4**);

   This was because of the following factors:

   i) The environmental conditions (**paragraph 38**);

   ii) The light output from the red wig-wag light units was lower than specified and was hard to see against the bright sunlight (**paragraph 45, Recommendation 1**);

   iii) The light output of the lamps was lower than specified and the red lenses fitted to the wig-wag light units were of an obsolete design that did not meet their specification (**paragraph 54, Recommendation 1**);

   iv) The level crossing barrier was not conspicuous against the background when viewed from the north side of the crossing (**paragraph 59, Recommendation 2**);

   v) Network Rail did not have a process for checking that existing wig-wag lamps and lenses met their specification (**paragraph 62, Recommendation 4**);

b. Network Rail's level crossing management process did not adequately recognise and deal with the effect of sunlight on the visibility of crossing equipment (**paragraph 70, Recommendation 2**); and

c. Network Rail had no ongoing plan to replace 36 W wig-wag units (**paragraph 83, Recommendation 1**).

Observations

108 The following observations were made:

a. The brightness of LED wig-wag units is at the bottom of the range specified for road traffic lights in the European standard and there is no mechanism in place to ensure that the output of wig-wag light units remains comparable to that of road traffic lights (**paragraph 89, Recommendation 3**); and

b. The design of road traffic light signals used at level crossings does not incorporate a positive 'clear' indication to the road user (paragraph 94). The RAIB makes no recommendation on this as the findings from the RSSB T756 research did not show a case for the wholesale replacement of existing wig-wags.

Previous RAIB recommendations relevant to this investigation

109 The following recommendations, which were made by the RAIB as a result of its previous investigations, have relevance to this investigation.

Fatal accident at Wraysholme crossing, Flookburgh, Cumbria, 3 November 2008. RAIB report 26/2009, published 7 October 2009

110 **Recommendation 1:** *The intention of this recommendation is to ensure that road users are able to discern the aspects of road traffic signals that protect automatic level crossings in all foreseeable conditions.*

Network Rail should:

a. revise its method of automatic level crossing inspection and assessment so that it identifies road traffic signals that are difficult to discern because of the effect of sunlight, lamp unit performance and alignment; and

b. draw up and implement a programme to improve the identified crossings, with those presenting the highest risk improved ahead of those of lower risk.

111 Network Rail's primary response to the recommendation was the fitment of LED light units to all AOCL, and a number of AHB, level crossings. Although the recommendation had indicated the need for a review of methods of automatic level crossing inspection and assessment, Network Rail elected to select the AHB crossings for upgrade by applying its existing risk management processes (ie ALCRM assessments, supported by existing guidance provided in the level crossing risk management toolkit). Network Rail considered that these processes were sufficient to identify those high risk AHB crossings that were also at particular risk from sunlight effects. In this way 50 AHB crossings were identified for upgrading (this list did not include the crossing at Beech Hill which was not assessed as being prone to problems with sunlight; paragraph 75).

112 The ORR reported that Network Rail had advised on 26 October 2010 that it had issued 'Technical Instruction TI 136: Alignment of Level Crossing Road Traffic Signals (Wig-wags)' in April 2009 to define the method of checking the alignment of wig-wag signals. Network Rail stated that light units that need to be realigned or amended would be highlighted by the Level Crossing Inspector Maintainers and reported as a defect so that Signalling Technicians could correct the alignment.

113 During the early part of 2010 Network Rail worked with RSSB to update the level crossing risk management toolkit. The update issued in March 2010 reflected new learning from a number of accident investigations, including Wraysholme, and recent railway industry research. It included a new 'human factors issue', relating to sunlight. This was described as 'reflected sunlight/wash-out' and guidance was provided on related mitigation measures (with direct reference to Wraysholme where 'wash-out' had been a factor). Although these measures did not include the provision of LEDs, guidance was provided that indicated that the problem of 'wash-out' is less apparent with LEDs than for 'standard bulbs'.

114 The RAIB has been unable to find evidence of any actions that were taken, following the issue of Wraysholme recommendation 1, to improve the ability of risk assessors to identify that sunlight may be a problem at an automatic level crossing, or to assess the performance of existing light units.

115 In August 2010 the ORR reported to the RAIB that it considered Network Rail had implemented this recommendation.

Fatal accident at Halkirk level crossing, Caithness, 29 September 2009. RAIB report 16/2010, published 23 September 2010

116 **Recommendation 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.

117 The ORR reported that Network Rail advised on 26 January 2011 that it had produced a briefing presentation for its Operations Risk Advisors (ORAs). This presentation was made to the ORA Group on 26 January 2011. The additional guidance was aimed at reinforcing existing processes and explaining the need to consider wider issues when deciding upon risk reduction options at level crossings and not only basing decisions on the risk score taken from ALCRM and the associated cost benefit analysis. The presentation asked the risk assessors to also consider the accident history and the levels of misuse of the crossing but gave no suggestion on how to deal with other factors, such as sunlight risk.

Actions reported as already taken or in progress

118 Network Rail replaced the 36 W wig-wag units at Beech Hill with LED units on 16/17 December 2012. The RAIB viewed the crossing in similar conditions to the day of the accident on 13 January 2013. Photographs were taken of the crossing while it was activated at the same time of day and from the same positions in the road as on the day after the accident. The exposure time of the photograph is short compared to the time of the flash cycle and it is possible that the 36 W lamps may not have reached full output at the instant of exposure. However, the photographs give an indication of the visibility of the crossing and wig-wags and confirm the observations made on the day after the accident (paragraph 43).

119 The picture in figure 7 was taken from the same place as figure 6; a point in the road 45 metres back from the nearside wig-wag, which is between the Highway Code stopping distances for speeds of 40 mph and 50 mph (36 metres and 53 metres respectively). The average speed for most vehicles over the crossing was 49 mph (paragraph 42). The position of the photographer in figures 6 and 7 was therefore at approximately the point at which a typical driver would start to brake for the crossing.

Figure 7: The view from the same point as figure 6, in similar conditions on 9 January 2013, with standard LED wig-wag light units

120 Network Rail issued guidance to its signalling maintenance staff and level crossing inspector maintainers on the risk of wig-wag signals being affected by sunlight (Network Rail Noticeboard item NB 122, 18 February 2013). The notice described how the sun could affect a road user's ability to see the red lights when shining from behind the wig-wags (as at Beech Hill) or from behind the observer (as at Wraysholme and Halkirk). The remedial action suggested was to fit longer hoods to the lamp units. This would only be an effective remedy in situations where the sun is shining from behind the observer. No effective advice was given on how to deal with situations where the sun is shining from behind the wig-wags towards the observer.

Recommendations

121 The RAIB has made the following recommendations[15]:

1 *The purpose of this recommendation is to replace, with LED units, all remaining 36 W wig-wags at level crossings, with those having 'Bliss' lenses a priority. Network Rail issued Special Inspection Notice SIN121 on 9 May 2013 to locate all such crossings on its infrastructure. This inspection is to be completed by 27 September 2013.*

Infrastructure managers should determine which level crossings are fitted with 36 W road traffic light signal (wig-wag) units or with 'Bliss' lenses and draw up a time bound plan so that their replacement with LED units is done as soon as possible, those with 'Bliss' lenses being dealt with first.

2 *The purpose of this recommendation is to devise a method of assessing the risk of a bright background and glare preventing wig-wags, and other crossing equipment, from being seen and propose means of mitigating this (eg higher powered LED wig-wags, barrier skirts or other means of improving barrier conspicuity).*

Infrastructure managers should put in place a method of identifying those locations where there is a significant risk from sunlight impairing the visibility of level crossing wig-wags and barriers, propose suitable mitigation measures where appropriate and implement these measures. The method should be based on suitable research and include specific consideration of the possibility of glare, and the wig-wags being seen against a bright background and the barriers against a dark background, taking into account environmental factors and seasonal daytime variations. A programme of training and briefing of the staff carrying out the assessment should be implemented.

continued

[15] 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 and the Department of Regional Development (NI) to enable them to carry out their duties under regulation 12(2) to:

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

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

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

3 *The purpose of this recommendation is to introduce a new 'brighter' type of LED wig-wag for use at sites where sunlight glare has been identified as a factor.*

Infrastructure managers should, in conjunction with the other industry parties, develop a new type of wig-wag unit with higher luminous intensity than the existing LED units for use at crossings where high background luminance and sunlight glare is a particular problem, and install these units at the appropriate locations.

4 *The purpose of this recommendation is to ensure the inspection and maintenance process confirms that wig-wag light units continue to meet their specification (types other than 36 W, which will have been dealt with in Recommendation 1). This may be achieved by means of testing/ inspection or by replacing lamps at the end of a defined service life.*

Infrastructure managers should enhance the inspection and maintenance process for wig-wag lamps to provide assurance that they continue to meet their specified performance standard.

Appendices

Appendix A – Glossary of abbreviations and acronyms

AHB	Automatic Half Barrier
ALCRM	All Level Crossings Risk Model
AOCL	Automatic Open Crossing Locally Monitored
cd	Candela, the SI unit of luminous intensity
LED	Light Emitting Diode
MCB – CCTV	Manually Controlled Barriers with Closed Circuit Television Monitoring
MCB – OD	Manually Controlled Barriers with Obstacle Detection
ORA	Operational Risk Advisor
RTLS	Road Traffic Light Signals (wig-wags)

Appendix B – Glossary of terms

Boom lamps	Small lights attached to the level crossing booms to improve their visibility in the dark.
Brightness	The attribute of an area perceived as self-luminous which permits it to be classed within the range very dim to very bright or glaring.
cd (candela)	The SI unit of luminous intensity.
Candelas per square metre (cd/m^2)	The SI unit of luminance.
Gate box	A control point provided for the supervision of a level crossing(s) which is not controlled directly by a signal box.
Glare	The visual consequence of viewing light sources with high luminous intensity or surfaces with high luminance. Glare scales typically range from discomfort glare to disability glare.
Lamp unit	In this report, lamp unit is defined as the complete assembly of housing, reflector, lamp holder, lamp (bulb) and lens which makes up one of the three lights on the wig-wag back board.
Level crossing order	A legal order made under the Level Crossings Act 1983 (and earlier Acts) which specifies the particular arrangements at a level crossing.
Lumen	The SI unit of luminous flux.
Luminance	The quotient of the luminous intensity in a given direction, by the projected area on a plane perpendicular to that direction. This quantity most closely describes the brightness of a surface.
Luminous flux	The total light energy emitted by a light source.
Luminous intensity	The quotient of the luminous flux emitted in a given direction by a point light source, in an infinitesimal cone containing that given direction, by the solid angle of that cone.
NRN Radio	National Radio Network radio – a train to control radio system.
On train monitoring recorder	A data logger fitted to trains which records key information such as speed, brake operation, etc.
Track circuit	A device to detect trains which involves passing an electrical current through the rails.
Track circuit block	The system of signalling the railway where safe operation of trains is achieved by allowing only one train at a time to occupy a section of track fitted with a track circuit (a track circuit is a device to detect the presence of a train).

Treadle	A mechanical arm attached to the side of the rail which is operated by the wheels of a passing train.
Urgent safety advice	A communication to industry parties issued by the RAIB to inform them of an important safety issue of immediate relevance.
Whistle board	A sign placed at the side of the railway to remind train drivers to sound their horn to provide a warning to users of a crossing.
Wig-wag	The flashing red lamps fitted at level crossings to warn road traffic.

Appendix C – Urgent Safety Advice

RAIL ACCIDENT INVESTIGATION BRANCH

URGENT SAFETY ADVICE

1. INCIDENT DESCRIPTION			
LEAD / INSPECTOR		CONTACT TEL. NO.	
INCIDENT REPORT NO	619	DATE OF INCIDENT	4 December 2012
INCIDENT NAME	Collision at Beech Hill AHB crossing		
TYPE OF INCIDENT	Collision between train and car		
INCIDENT DESCRIPTION	A car collided with the lowered barrier at Beech Hill AHB on the Gainsborough – Doncaster line and ran into the path of a Lincoln – Doncaster passenger train. The train struck the car, fatally injuring a child who was a passenger in the car. The weather conditions at the time were bright sun with the sun low in the sky and shining directly towards the approaching car. The road surface was wet. The crossing was fitted with a data logger which showed that the barriers were down and the wig wag signals were working at the time that the car approached the crossing.		
SUPPORTING REFERENCES			

2. URGENT SAFETY ADVICE	
USA DATE:	
TITLE:	Level crossing road traffic light signals ('wig wag' signals)
SYSTEM / EQUIPMENT:	Wig wag road traffic light signals fitted with 36W lamps and lenses manufactured by E.W.Bliss 'Eagle Signal Company'.
SAFETY ISSUE DESCRIPTION:	The light output of wig wag signals of this type is well below the minimum luminous intensity specified in BR908:1969 and can make the signals very difficult to discern in conditions of bright sunlight and glare.
CIRCUMSTANCES:	The RAIB commissioned testing of the Beech Hill wig wag road traffic lights. These tests have found that the light output of the red light unit is substantially lower than allowed by the specification for 36W wig wag lamp units (BR908:1969). The specification (and the modern standard for LED wig wag lamps) requires a minimum luminous intensity of 500 candelas on the axis of the lamp. The red light units tested from Beech Hill crossing gave maximum luminous intensities of between 101 and 222 candelas. The colour of the light emitted from the red light units was also outside the range allowed in the specification, being too far into the deep red area, which can make them harder to see for people with certain types of eyesight defect. The lamps themselves were found to be well below the specified luminous flux and this was compounded by the lenses that were fitted. These are marked 'E.W.Bliss Eagle Signal Company US patent' on the inside and branded with an eagle motif on the outside surface of the lens at its centre (this branding itself does not comply with the BR908:1969 specification, which requires a smooth outer surface to the lens).
CONSEQUENCES	It is potentially very difficult to detect that wig wag road traffic lights of this type are illuminated in adverse ambient lighting conditions, such as bright sunlight shining from behind the signal towards the oncoming road traffic.
REASONS FOR ISSUE:	The RAIB has found that these lenses are in use at another AHB crossing where an incident occurred (Cridling Stubbs AHB crossing on the Shaftholme Jn. – Knottingley line, 27 Feb 2013). This incident involved a motorist not noticing that the wig wag road traffic lights were operating when approaching the crossing with the sun low in the sky behind the signals. This incident is being considered in the Beech Hill investigation. There may be other crossings where this type of lamp and lens are still in use in wig wag road traffic lights. This urgent safety advice notice is issued to make infrastructure managers aware of the risk of road vehicle drivers not seeing illuminated wig wag road traffic lights that are fitted with 36W lamps and this type of lens. The RAIB found that changing the lens for a more modern type, whilst it improved the light output, did not raise the luminous intensity to a sufficient level to meet the BR908:1969 specification.

USA SIGN-OFF*			
INSPECTOR NAME:		CI NAME:	
INSPECTOR SIGNATURE:	ELECTRONIC COPY	CI SIGNATURE:	ELECTRONIC COPY
DATE:	16 April 2013	DATE	16 April 2013

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