Rail Accident Investigation Branch

Rail Accident Report

Near miss between a passenger train and cars at Norwich Road level crossing, New Rackheath, Norfolk
24 November 2019

Report 15/2020
December 2020

This investigation was carried out in accordance with:

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

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Preface

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. 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.

RAIB's findings are based on its own evaluation of the evidence that was available at the time of the investigation and are intended to explain what happened, and why, in a fair and unbiased manner.

Where RAIB has described a factor as being linked to cause and the term is unqualified, this means that RAIB has satisfied itself that the evidence supports both the presence of the factor and its direct relevance to the causation of the accident or incident that is being investigated. However, where RAIB is less confident about the existence of a factor, or its role in the causation of the accident or incident, RAIB will qualify its findings by use of words such as 'probable' or 'possible', as appropriate. Where there is more than one potential explanation RAIB may describe one factor as being 'more' or 'less' likely than the other.

In some cases factors are described as 'underlying'. Such factors are also relevant to the causation of the accident or incident but are associated with the underlying management arrangements or organisational issues (such as working culture). Where necessary, words such as 'probable' or 'possible' can also be used to qualify 'underlying factor'.

Use of the word 'probable' means that, although it is considered highly likely that the factor applied, some small element of uncertainty remains. Use of the word 'possible' means that, although there is some evidence that supports this factor, there remains a more significant degree of uncertainty.

An 'observation' is a safety issue discovered as part of the investigation that is not considered to be causal or underlying to the accident or incident being investigated, but does deserve scrutiny because of a perceived potential for safety learning.

The above terms are intended to assist readers' interpretation of the report, and to provide suitable explanations where uncertainty remains. The report should therefore be interpreted as the view of RAIB, expressed with the sole purpose of improving railway safety.

Any information about casualties is based on figures provided to RAIB from various sources. Considerations of personal privacy may mean that not all of the actual effects of the event are recorded in the report. RAIB recognises that sudden unexpected events can have both short- and long-term consequences for the physical and/or mental health of people who were involved, both directly and indirectly, in what happened.

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

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Near miss between a passenger train and cars at Norwich Road level crossing, New Rackheath, Norfolk, 24 November 2019

Contents

Summary

On 24 November 2019, the barriers at Norwich Road level crossing, near New Rackheath, Norfolk, lifted as a passenger train from Norwich to Sheringham was approaching. Two road vehicles crossed the railway in front of the train, which reached the crossing less than half a second after the second road vehicle was clear.

The investigation found that there was contamination of the railhead in the area caused by leaf-fall and atmospheric conditions. This contamination had not been removed because there were no railhead treatment trains on the Norwich to Sheringham line at weekends. The narrow band on which trains' wheels were running on the contaminated railhead, which was a consequence of the introduction of new trains, left the wheel-rail interface vulnerable to a poor electrical contact in the event of contamination. This caused the level crossing equipment to misinterpret the position of the train, and consequently it opened the crossing to road traffic while the train was closely approaching.

RAIB has made three recommendations addressed to Network Rail regarding the planning of autumn railhead treatment, guidance on the introduction of new trains and the configuration control of signalling equipment. RAIB also identified two learning points concerning the investigation of incidents and the signalling design process.

Introduction

Definitions

1 Metric units are used in this report, except when it is normal railway practice to give speeds and locations in imperial units. Where appropriate the equivalent metric value is also given.

2 The report contains abbreviations. These are explained in Appendix A. Sources of evidence used in the investigation are listed in Appendix B.

The incident

Summary of the incident

3 At 19:54 hrs on Sunday 24 November 2019, the barriers at Norwich Road level crossing, on the outskirts of Norwich, opened to road traffic while a passenger train was approaching. Two road vehicles crossed just in front of the train, one from each side of the railway.

4 On seeing the crossing barriers rising, the driver of the train applied the emergency brake, but the train was not able to stop before reaching the crossing. The car moving from right to left cleared the crossing less than half a second before the train reached it, by which time the train was travelling at around 40 mph (64 km/h).

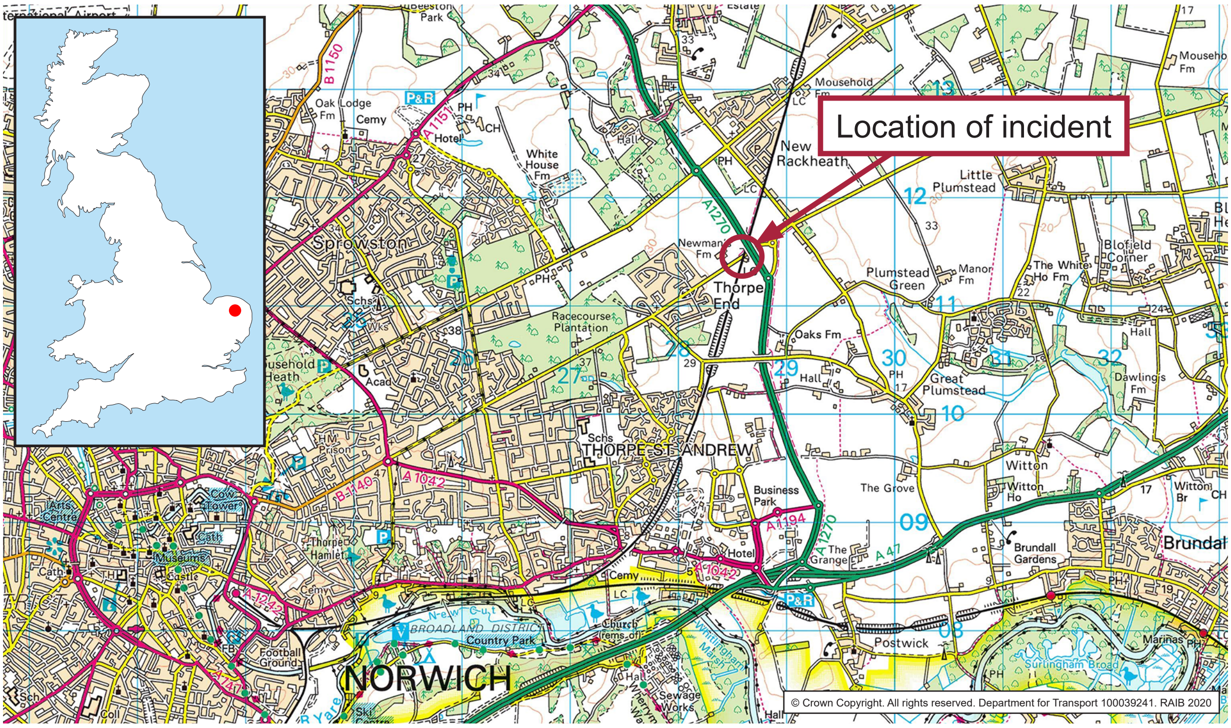

Figure 1: Extract from Ordnance Survey map showing location of incident

5 No collision occurred, but train services were reduced with special controls applied to this and other crossings on the route until modifications had been made to their operation. These were completed at the end of December 2019.

Context

Location

6 The incident occurred at Norwich Road automatic half barrier (AHB) level crossing on the line from Norwich to Cromer and Sheringham (figures 1 and 2). The level crossing is between Whitlingham Junction and Salhouse station, at 4 miles 20 chains[1] from Norwich. The line is part of Network Rail's Anglia route.

[1] A unit of length equal to 66 feet or 22 yards (around 20 metres).

7 The railway at this point comprises two lines, the down Cromer branch (the down line) used by trains heading towards Cromer, and the up Cromer branch (the up line) used by trains heading towards Norwich. The maximum permitted line speed on the down line, where the incident occurred, is 55 mph (88 km/h) for 'sprinter' trains (including the class 755 involved[2]) and 45 mph (72 km/h) for other types of train.

8 On approach to the level crossing, the railway is in a shallow cutting with trees and shrubs on the lineside.

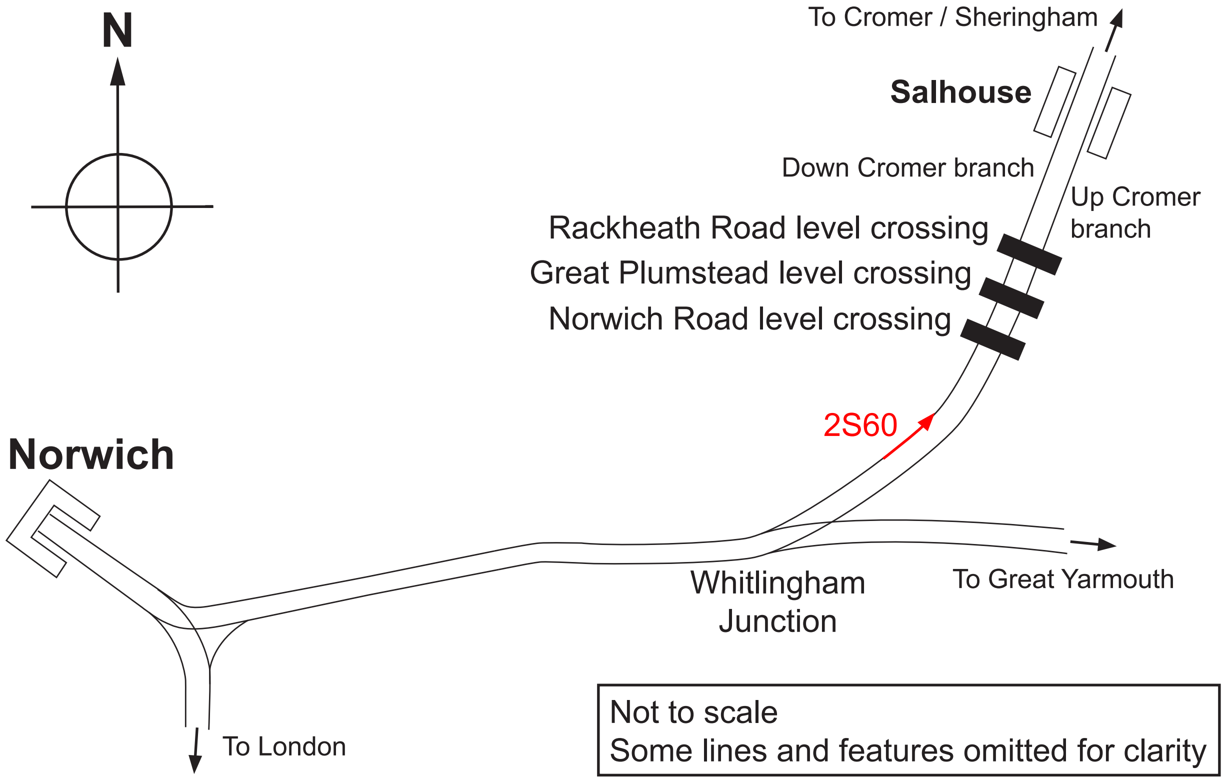

Figure 2: Track layout

Organisations involved

9 Network Rail owns, operates and maintains the infrastructure.

10 Abellio East Anglia Limited, trading as Greater Anglia, was the operator of the train and employer of the driver and instructor driver.

11 Stadler Rail is the manufacturer and maintainer of the train.

12 Alstom, through mergers and acquisitions, is the manufacturer of the level crossing predictor equipment.

13 Each of these organisations freely co-operated with the investigation.

[2] 'Sprinter' permissible speeds were originally applicable to multiple units in the 15x series known as Sprinters. However, the category has since been extended to include other types of train with similar weight and performance characteristics. The summary of rolling stock/infrastructure compatibility issued by Network Rail for class 755 trains on Greater Anglia routes permitted them to operate at multiple unit and sprinter speeds. The differential speeds on the routes operated by Greater Anglia have been reviewed and are being re-designated as multiple unit speeds.

Train involved

14 The train, reporting number 2S60,[3] was the 19:45 hrs Greater Anglia service from Norwich to Sheringham. It was formed of unit 755416, a single five-car class 755, bi-mode multiple unit. These trains are capable of taking power from overhead wires or generating their own electric power, using diesel generators housed in a power car between the second and third passenger coaches (figure 3).

15 Class 755 trains were built for Greater Anglia by Stadler Rail and were introduced into regular passenger service between Norwich and Sheringham in early November 2019.

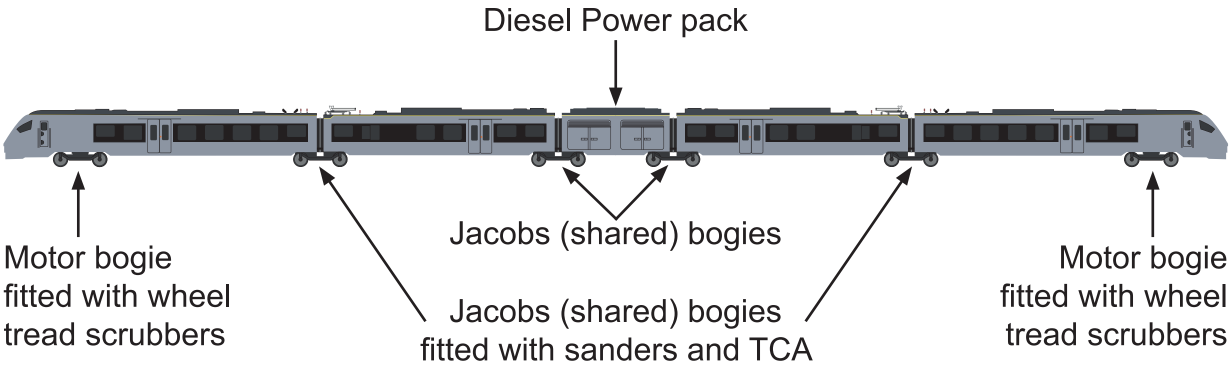

Figure 3: Layout of a five vehicle class 755 train

Rail equipment/systems involved

16 The down line is laid with flat-bottom jointed rail, dating from 1958, on timber sleepers.

17 Lineside signalling is operated in accordance with track circuit block regulations and trains are detected by axle counters, although these are not used as part of the level crossing controls. Trains are signalled from Trowse Swing Bridge signal box. Norwich Road level crossing and five others in the area are operated by HXP3 level crossing predictors (see paragraph 38).

Staff involved

18 The train was driven by a trainee driver who had been employed by Greater Anglia since February 2019. The driver was being supervised by a driver instructor who had been a Greater Anglia driver since 2006.

19 The way in which the train was driven was not causal to the incident. RAIB recognises that, by realising what was happening and rapidly applying the emergency brake, the train crew may have avoided a serious accident.

External circumstances

20 The incident occurred around three hours after dusk, when the weather was dry and the air temperature was around 10°C. There had been fog and haze earlier in the day, and some light rain the previous day.

21 The weather, in particular the humidity levels, in the 48 hours prior to the incident may have been a factor in the incident (see paragraph 79).

The sequence of events

Events preceding the incident

22 Class 755 trains were introduced on the Norwich to Sheringham service in 2019, replacing older units of classes 153, 156 and 170. By the autumn, after test runs during the spring and summer, they were operating the majority of services on the line. At the time of the incident, Greater Anglia operated one train an hour from Norwich to Sheringham seven days a week, with shorter operating hours on Sundays.

23 The line is also used occasionally by freight trains. The last of these to pass Norwich Road level crossing in the down direction was on Thursday 21 November.

24 During the autumn leaf-fall season, a railhead treatment train (RHTT) operated over the line as far as Cromer every weekday morning. The last of these before the incident passed over Norwich Road level crossing at approximately 12:00 hrs on 22 November. RHTTs use a combination of water jets to remove contamination from the railhead and adhesion modifiers, to reduce train wheel slip and slide under acceleration and braking.

25 On 23 November, the barriers at Norwich Road level crossing had failed to rise after the passage of an up-direction train. This fault created a situation that was safe but potentially caused delays to trains and to road users (known as a 'right-side' failure). A Network Rail fault team attended and attributed the failure to poor railhead condition. As a result, a mobile operations manager (MOM) manually treated the railhead on the up line with a Network Rail approved cleaning agent in the early afternoon of 24 November.

Events during the incident

26 At 19:53 hrs on 24 November, train 2S60 was approaching Norwich Road level crossing. In the driving cab were a trainee driver and an instructor driver. When the train was around 150 metres from the crossing, and travelling at approximately 45 mph (72 km/h), the instructor driver saw the barriers rising ahead of the train. The instructor driver told the driver to apply the emergency brake and sound the horn, which he did.

27 As the train approached the crossing, a car crossed from left to right, then another from right to left. A second vehicle approaching from the right stopped before reaching the crossing.

28 Eight seconds after the barriers started to rise, and just before the train reached the crossing, the amber road traffic lights came on as the level crossing warning sequence restarted. The train missed the rear of the vehicle travelling from right to left by less than half a second (figure 4).

29 The train stopped around 230 metres beyond the crossing, where the driver made a railway emergency call using the GSM-R radio equipment in the train's cab and reported the incident to the signaller.

Figure 4: Vehicles crossing ahead of the train (courtesy of Greater Anglia)

Events following the incident

30 After a few minutes, the driver and instructor agreed with Greater Anglia control that they were fit to continue and drove the train on to Sheringham. The incident was not reported to RAIB by Network Rail, but was identified by RAIB during its regular review of Network Rail's daily log. The same day, RAIB decided to carry out a preliminary examination of the event because of the serious nature of the incident and the narrow margin by which an accident had been avoided.

31 On the evening of 24 November, a Network Rail signalling fault-finding team investigated the reported failure of the crossing and found that the crossing was working as designed. Network Rail supplied RAIB with details of these post-incident tests. This team also found and photographed railhead contamination, in the form of a solid black film on the railhead. No samples of this contamination were retained for analysis.

32 Following the incident, Network Rail imposed a 20 mph (32 km/h) speed restriction over the crossing, and crossing operators were employed at each of the three AHB crossings in the area, manually operating each crossing via the local control unit on the approach of every train.

33 The following Sunday (1 December), an abnormal operation of Rackheath Road level crossing (500 metres on the Cromer side of Norwich Road level crossing) occurred, which resulted in the barriers failing to raise after the passage of a train, a right-side failure. As part of Network Rail's subsequent investigation, railhead contamination was found and sent for analysis.

The investigation

34 Following the incident, Network Rail in consultation with RAIB commissioned Atkins Technical Investigation Centre to undertake tests on site to identify the cause of the failure. Atkins installed monitoring equipment in the equipment room at Norwich Road level crossing on 4 December 2019 and monitored the crossing continuously until 1 January 2020. Network Rail made changes to the timers in the crossing controls, and fitted treadles, a form of track mounted switch that detects the passage of trains, on the approach to each of the crossings. These were commissioned in late December 2019.

35 While the speed restrictions and manual operation of the crossing were in force, passenger services on the line were terminated at Cromer, because the increased travel time meant that the normal timetable could not be operated.

36 Up until 28 December 2019, the monitoring undertaken by Atkins found a number of instances where the predictor system did not consistently identify the position of all approaching trains. After this date the system was found to correctly identify the position of approaching trains (see paragraphs 39 to 46).

37 The normal line speed and timetable were restored at the end of December 2019 once the leaf-fall season had finished and additional equipment had been installed (see paragraphs 136 and 137).

Background information

HXP3 Predictors

38 A level crossing predictor can be used in conjunction with automatic level crossings. Its purpose is to predict how long it will be before an approaching train arrives at the crossing, and operate the crossing equipment in a way that gives a consistent closure time for road users, irrespective of the train's speed. The HXP3 predictor uses a special type of track circuit to achieve this. The Norwich to Cromer line was the site of the pilot installation of level crossing predictors on the British railway network.

39 The pilot installation was commissioned in 2000, and at the time of the incident HXP3 predictor units were operational at 10 level crossings on Network Rail's infrastructure, installed between 2000 and 2013. Worldwide there have been in excess of 25,000 units fitted, between 1992 and 2016. The manufacturer ceased production of the HXP3 predictor at the end of 2014 and began production of a newer product with similar functionality.

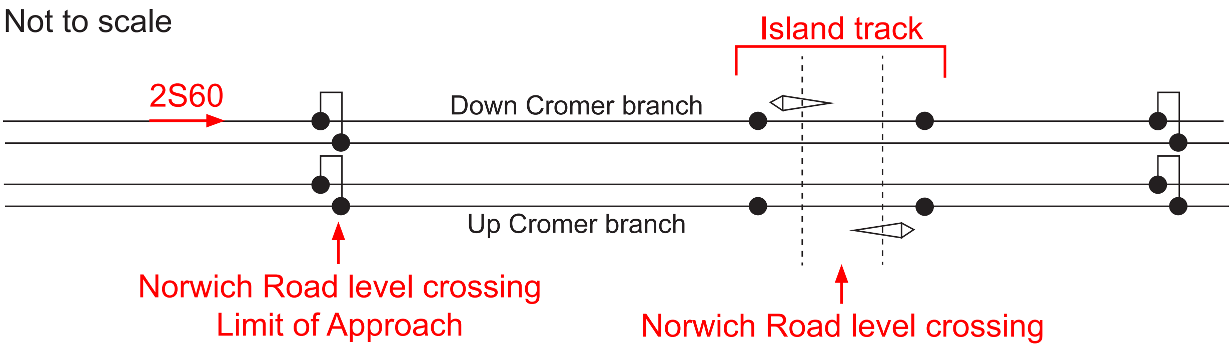

Figure 5: Predictor track layout

40 The HXP3 applies a low voltage signal to a rail at the crossing. In the absence of trains this signal passes through an electrical connection between the rails some distance from the crossing and returns to the predictor along the other rail. These connections are placed 1610 metres from the crossing, at locations known as the 'limits of approach' (figure 5). This distance is based on the time required to warn road traffic by illuminating the road traffic lights and closing the barriers (the warning time), and the permitted line speed for trains. There is a limit of approach on each side of the crossing on both the up and down lines. This allows the crossing to function normally for trains running in both directions on both lines, if necessary.

41 When a train travelling towards the crossing passes the limit of approach, the length of the electrical circuit reduces as the detection signal is returned to the crossing through the train's wheelsets.[4] The predictor compares the outgoing and incoming detection signals and the rate of change between them. When a change is detected, the signal is used to assess the train's speed and distance from the crossing. This allows the system to trigger the crossing closure sequence when the train is a set time away from the crossing, rather than a set distance away as happens in conventional installations. This has the advantage of providing users with a regular crossing closure time despite differing train approach speeds.

42 If the equipment operates as intended, the measured voltage plotted against time decreases or increases at an approximately uniform rate if the train is travelling at a steady speed (a straight line on the example shown in figure 6). On the other hand, train acceleration or deceleration results in a variable rate of change (a curved line).

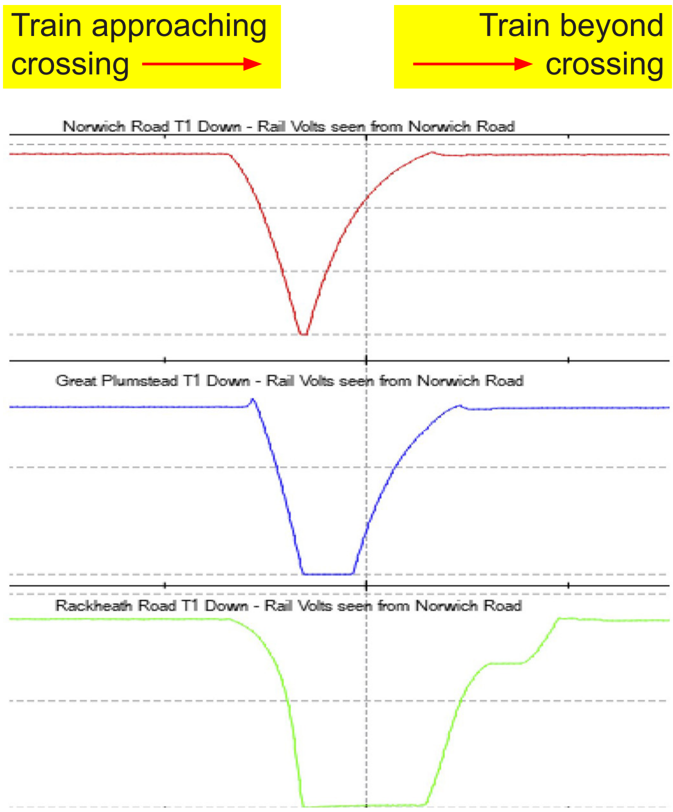

Figure 6: Normal voltage response (courtesy of Atkins)

43 As a train moves over a crossing it passes through a separately configured area of track in the immediate crossing area, known as the 'island', occupation of which keeps the crossing closed to road traffic. As a train subsequently moves off the island and away from the crossing it causes an increasing electrical resistance and an increased voltage difference at the crossing, which causes the HXP3 to end the closure and initiate raising of the barriers.

[4] When a train connects the two rails together with its wheels it is said to 'shunt' the track circuit, from the electrical meaning of shunt, to add a component with a very low value of resistance in parallel with another component.

44 While a train is approaching the crossing, one or more of the following potential anomalies could affect the correct operation of the crossing. These are:

- the HXP3 system detects an increased electrical resistance (which it would interpret as an increased length of rail) and responds as if the train is further from the crossing than is actually the case (figure 7)
- the HXP3 system loses detection of the approaching train and responds by ending the crossing closure sequence, resulting in the barriers rising
- the HXP3 system detects no change in the electrical resistance, which it would interpret to mean that the approaching train is stationary, resulting in the crossing closure sequence ending and the barriers rising.

45 To avoid the closure sequence ending in the event of a short duration anomaly (such as a loss of detection) before the island track circuit has been occupied, the system has a 'loss of shunt' (LOS) timer which is initiated when the system no longer detects an approaching train. This timer prevents the ending of the closure sequence until a set time has passed. If an approaching train has not been detected at the end of the timing period the crossing closure sequence will end, the barriers will rise and the road traffic signals will stop flashing red.

46 The LOS timer can be set to any value between 4 and 99 seconds. The LOS timer at Norwich Road level crossing was set to 16 seconds, which was the default setting when delivered from the manufacturer.

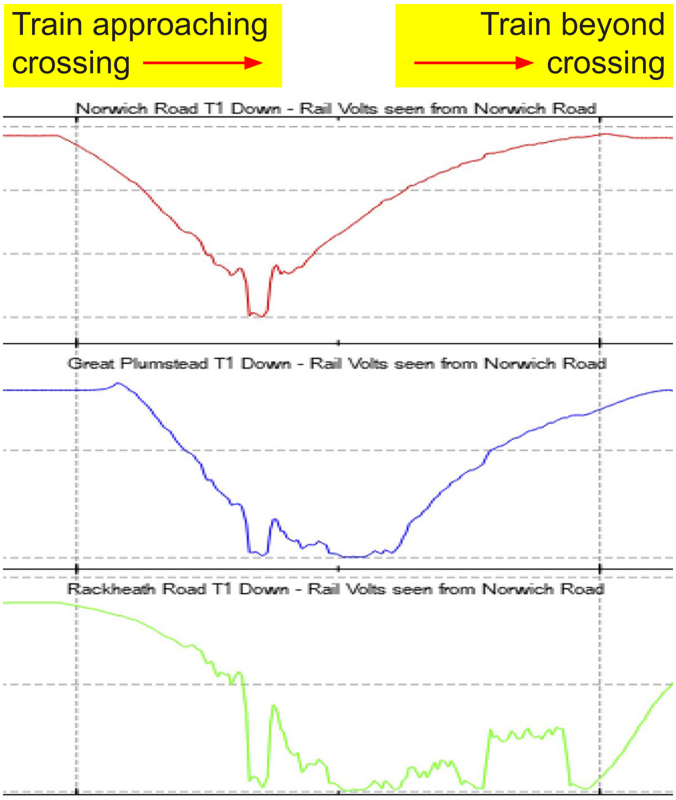

Figure 7: Voltage response with sporadic changes in resistance (courtesy of Atkins)

Analysis

Identification of the immediate cause

47 The level crossing opened to road traffic as the train was approaching, allowing cars onto the crossing.

48 Data recorded by the signalling system shows that the level crossing closure sequence operated as intended when the train was approaching. This was confirmed by the forward facing closed-circuit television (FFCCTV) from train 2S60, which shows that the crossing was active and the barriers were down until the train was around 8 seconds away from the crossing.

49 As the train approached the crossing, the FFCCTV recording shows the barriers rising, the flashing wig-wag lights extinguishing and the road traffic starting to move.

50 One car crossed in each direction as the train neared the crossing. The driver of the car travelling from right to left, which moved clear less than half a second before the train reached the crossing, stated that '*the barriers came down as normal. After a while the barriers raised, and the lights went out*'. Motorists then drove onto the crossing as they were entitled to do. There is no requirement for motorists to look for approaching trains at this type of crossing.

Identification of causal factors

51 The incident occurred due to a combination of the following causal factors:

- train detection equipment incorrectly reported the position of the approaching train (paragraph 52)
- the level crossing control system made insufficient allowance for incorrect operation of the train detection system (paragraph 100).

Each of these factors is now considered in turn.

Electrical connection at the wheel-rail interface

52 Train detection equipment incorrectly reported the position of the approaching train because of inconsistent electrical contact at the wheel-rail interface.

53 From analysis of FFCCTV, signalling data, and the on-train data recorder (OTDR), RAIB concluded that the predictor system:

- correctly identified the train as approaching and began the closure sequence when the train was 1280 metres and 66 seconds away from the crossing.

- ceased to correctly identify the approach of the train when it was 515 metres (28 seconds) away. It is not possible to know whether the system had lost detection of the train, or interpreted the data as indicating a train which was stationary or moving away from the crossing, as this data is only stored until the next train passes through the crossing. The loss of the recognition of the train's approach caused the LOS timer to end the level crossing closure sequence 16 seconds later, which led to it raising the barriers when the train was 200 metres (12 seconds) away.
- identified the train as approaching and began the closure sequence again when the train was 83 metres (4 seconds) away.

54 No faults were found during post-incident signalling failure testing by Network Rail or during analysis of data recorder downloads undertaken by Network Rail and Alstom.

55 The monitoring undertaken by Atkins (paragraph 34) found that the predictor system equipment was working correctly, but that in some instances the electrical response of the system to approaching trains indicated that they were not making a consistent electrical contact between the running rails. On some days, as many as 67% of trains registered an inconsistent pattern of electrical contact with the rails. The number of trains with such patterns declined after 20 December. The last recorded inconsistent pattern was recorded on 22 December on the up line and 28 December on the down line.

56 Although anomalies were recorded, none of the recorded electrical responses of the system to approaching trains were sufficiently extreme to have resulted in an incident similar to the one on 24 November. This was probably because the enhanced RHTT schedule implemented after the incident was more effective in cleaning the railheads and therefore improving the wheel to rail electrical contact.

57 Most of the trains operating on the line during this period were class 755 units, with RHTTs, freight trains and older passenger diesel multiple units accounting for the rest. Atkins undertook detailed analysis of seven days of data, but was only able to reliably identify which type of train was involved for some of the data. From this subset, every occurrence of poor electrical contact except one, corresponded to a class 755 train.

58 The level crossing predictors were usually operated adequately by other passenger train types, freight trains and RHTTs, though data from these other types was limited because of their relative infrequency compared to class 755 trains.

59 Surface contamination at the wheel-rail interface can increase the contact resistance, causing the predictor to conclude that a train was moving away from the crossing, not present or stationary (paragraph 44). The precise electrical details of the issue which caused the predictor to incorrectly determine that train 2S60 was no longer approaching are not known, because the relevant electronic data was overwritten when subsequent trains passed over the crossing.

60 As part of its analysis, Atkins measured the voltages in the rails associated with the predictors. These were around 0.3V at the transmitter and less than 0.1V at the limit of approach. This low level of voltage is considered sufficient by the manufacturer because the system is looking for a change in the returned signal compared to the output. It is not comparable with higher voltages required for the operation of a relay in a conventional track circuit. The manufacturer confirmed that these figures were in line with design expectations, and had been able to reliably detect trains, with both fewer axles and lighter wheel loads than class 755s, since 2000 in the UK.

61 A consequence of using a low voltage is that the likelihood of the predictor track circuits being able to break down railhead contamination resistance is small. However, there is little evidence that a conventional track circuit would have performed significantly better in this respect.

62 Manufacturer's measurements of wheel-to-wheel electrical resistances, before assembly of the wheelsets into bogies, found resistances of less than 2 milliohm (mΩ) across the wheelsets of the train involved in the incident (standards permit a maximum of 10 mΩ). Direct measurements of the wheelset resistance were not undertaken after the incident because there are many possible current paths from one wheel to the other once the wheelset is in a vehicle bogie. Post-incident testing found that the track circuit assisters[5] (TCA) (see paragraphs 107 to 109) fitted to the train generated a current compliant with standards, which is only possible with a good electrical connection between the wheels.

63 For a nine-day period commencing on 8 December 2019, Atkins tested for background electrical interference from trains or other lineside sources which might affect the correct operation of the crossing. The tests were conducted with the HXP3 operational, so it was not possible to measure any interference at the frequency transmitted by the predictor. Following the testing, Atkins concluded that no electrical interference capable of causing the HXP3 to malfunction was identified in the rails, although it did identify background interference near the operating frequency. This interference had a peak value around the acceptable limit for reliable train detection set by Alstom, the HXP3 manufacturer.

64 Alstom stated that where interference at the operating frequency breached the prescribed threshold value, it might cause the HXP3 to show occupied when no train was present, a right-side failure. However, in Alstom's opinion, background interference cannot cause the predictor to 'lose' a train because the wheels of the train would equalise the voltage, by completing a circuit between the rails to neutralise the interference.

65 RAIB commissioned an independent consultant to review the testing undertaken by Atkins. The consultant concluded that the Atkins report was generally correct in its analysis relating to the level of background interference at the operating frequency. The consultant also concluded that it is highly unlikely that such interference, if present, would produce the events seen during the incident. However, with the limited evidence gathered, the consultant could not completely discount electrical interference without undertaking additional testing and analysis.

[5] These devices are referred to in the railway Rule Book as track circuit actuators, but while they may assist track circuit operation, they do not actuate track circuits.

66 Consideration of all the test findings, and the absence of external interference or identifiable equipment faults, leads to the conclusion that inconsistent electrical contact at the wheel-rail interface caused unreliable operation of the predictor system between 23 November and 28 December 2019 (it is possible that unidentified issues had occurred previously), but subsequently the system operated reliably.

67 Inconsistent contact arose due to a combination of the following:

- high levels of railhead contamination existed in the area, probably as a result of limited operation of the RHTT (paragraph 68)
- there was a narrow running band on the railhead, caused by the majority of rolling stock on the Norwich to Sheringham line being new and in similar condition to each other (paragraph 85).

Each of these factors is now considered in turn.

68 High levels of railhead contamination existed in the area, probably as a result of limited operation of the RHTT.

Railhead contamination and the operation of track circuits

69 The correct operation of track circuits requires a current path from one rail to the other through the wheels and axles of a train. This is usually a very reliable way of detecting trains, which generally have many wheelsets and heavy wheel loads. However, railhead and wheel contamination, caused by rust, organic matter such as leaves, sand, oil and grease deposits, or other insulating contaminants can restrict this electrical path. Interruption of this circuit can result in a train disappearing from the signalling system, or in the case of a predictor track, its position, direction or speed being incorrectly assessed by the system.

70 Leaf contamination on the railhead has been the subject of detailed research by railways in the UK and throughout the world. RSSB's review of low adhesion research published as part of T354 'Research into the characteristics of railhead leaf contamination' held the following relevant information:

- *'The influence of moisture on adhesion on leaf affected track is significant. As a result, early morning and early evening trains frequently encounter low adhesion, and a light shower of rain can have a sudden and dramatic effect on the train service. The leaf material does not adhere to the rail surface in wet conditions.'*
- *'Rain can affect significant lengths of track as can dew or other condensation effects. There are situations where the effect can be very localised, e.g. in short cuttings producing micro-climates.'*
- *'An 8-car multiple unit picked up as many as 60% of the leaves in the 4 foot and deposited them on the rails. The leaf like character [sic] to create a black thin continuous film on the wear band. The film is hard and difficult to scrape off the rail. […] Heavy rain will soften the film and passing wheels can then remove the film as quickly as it formed. Heavy rain also helps prevent leaf build up as soggy leaves are less mobile and leaves do not stick well to wet rails.'*

- *'Very low adhesion occurs as the paste moves from viscous liquid behaviour to that of a solid (or vice versa). This is more common on little used track or after a period of little traffic (the Monday morning effect). Also more common at certain times of the day when humidity effects may give rise to condensation on the rail. Humidity must be expressed relative to rail and not air temperature. As well as morning dew, condensation can occur when the rail temperature falls, e.g. in a cutting, or the local humidity is high, e.g. a wooded area.'*

71 RAIB found relatively little published research on the insulating effects of railhead contamination, most research having concentrated on its effect on adhesion. However, T354 concluded:

'The repeated crushing of a large number of leaves creates a hard, glazed, black leaf film which can completely cover the running band on the railhead. The film of leaf debris collects a high proportion of iron oxide rail debris forming a featureless black mass. This material, with its relatively low shear strength, can totally prevent metal-to-metal contact between wheel and rail, thus reducing adhesion (and forming an electrical insulating barrier).'

72 Photographs taken by Network Rail of the track on approach to the crossing on the evening of the incident, show a dark coating on parts of the rails (figure 8). Although some of this contamination was taken from the surface of the railhead, Network Rail did not preserve any samples (for reasons which RAIB has not been able to establish), so no analysis of the material was possible.

Figure 8: The railhead on approach to Norwich Road after the incident on 24 November 2019 (courtesy of Network Rail)

73 Analysis of samples taken from the rail on 2 December 2019 on the approach to Rackheath Road level crossing reported that the sample's principal constituent was microscopic carbon-based residue, but it was not possible to establish the origin of this material. There was also some iron oxide and silica material present (figure 9), which were likely to have been from rust and sand.

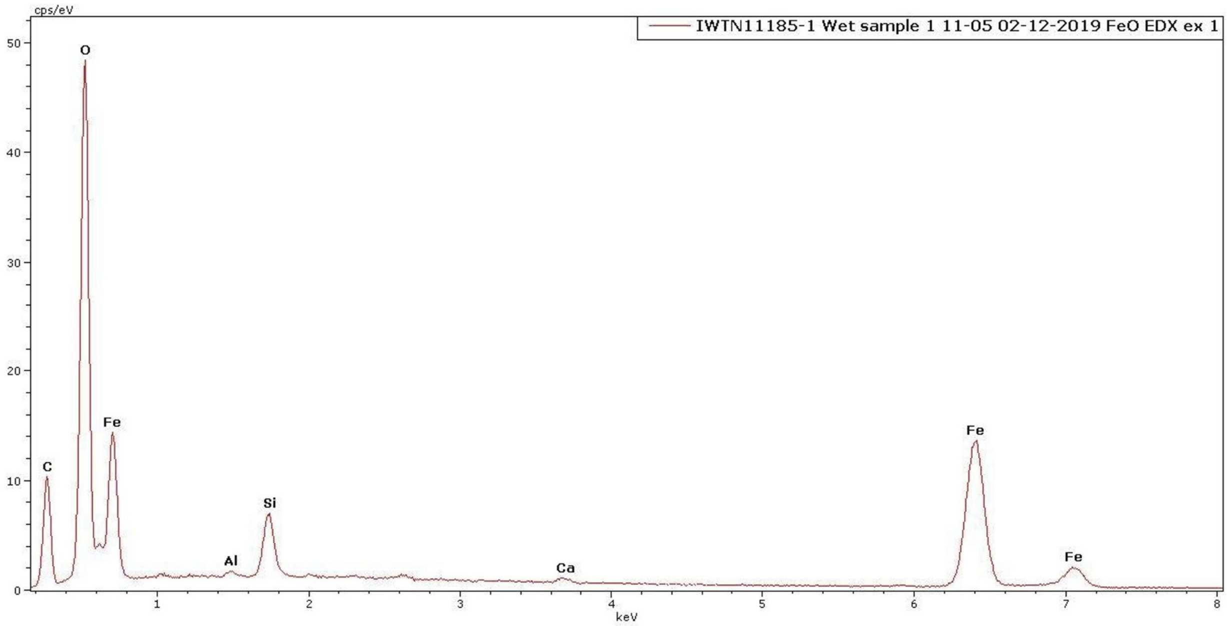

Figure 9: The chemical analysis of railhead contamination samples taken on 2 December at Rackheath Road (courtesy of Intertek)

74 The analysis undertaken as part of RSSB's research project T354 found that the major constituents of leaf-based railhead contamination, from several sample sites, were iron, oxygen, carbon and calcium. These chemical elements were also found in the sample taken on 2 December, with the addition of some silica deposits, most likely from sand deposited by trains during braking or as part of the adhesion modifier applied by the RHTT.

75 Given the local ecology and the nature of the contamination, it is highly likely that the railhead contamination on the rails on approach to Norwich Road level crossing was mainly caused by fallen leaves. If so, the dark areas visible in figure 8 would have affected the wheel-rail interface (as described by T354).

76 At the time of the incident, evidence of low adhesion, almost certainly caused by railhead contamination, is provided by analysis of the train's speed and distance covered (figure 10). Data extracted from the OTDR shows that after the driver applied the emergency brake, the train achieved an average deceleration rate of only 2.2% g for the first 190 metres, with considerable wheel slide protection (WSP) activity registered for all 12 axles. In full emergency braking, a modern train would be expected to achieve a deceleration rate of up to 12% g. During this period the speed recorded by the OTDR was erratic, indicating that wheel slide was occurring on the speed-recording axle.

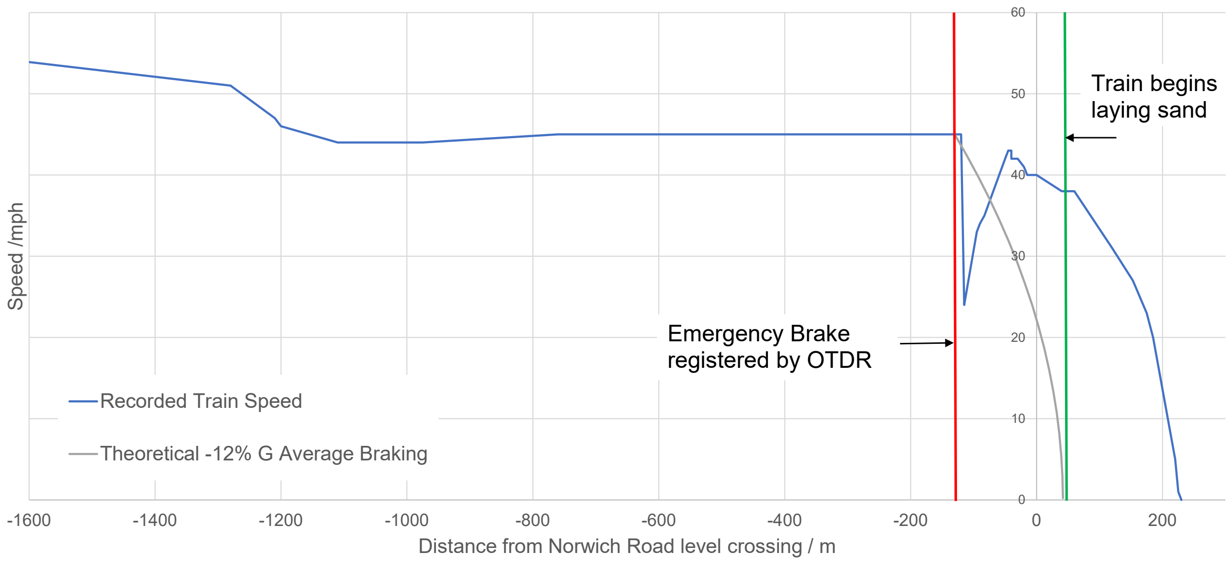

Figure 10: Recorded speed of the incident train from the limit of approach to Norwich Road level crossing until its stopping position, around 230 metres past the crossing

77 Once the train started depositing sand on the rails (see paragraph 121), the deceleration improved to an average rate of 9.3% g for the remaining 170 metres until the train came to a stand.

78 When an enhanced RHTT schedule was introduced after the incident, testing by Atkins found that the predictor crossings were more likely to behave normally for a short period after this train ran (figure 11). During this period the surface of the railhead would be damp, which would increase the mobility of the surface contaminants, meaning that the contamination was more likely to be displaced by the train's wheels (paragraph 70).

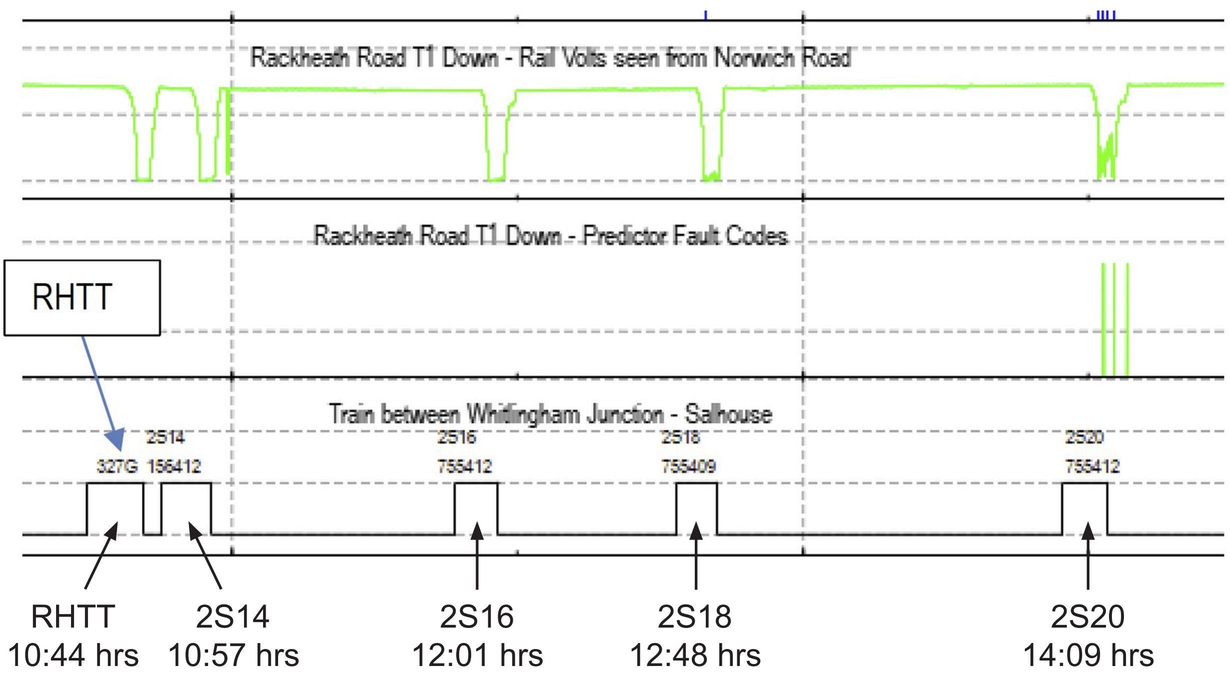

Figure 11: Changes in voltage response after passage of RHTT (courtesy of Atkins)

79 Weather records show that there was no measurable rainfall in the 48 hours before the incident. This is significant because moisture would have helped to keep the film of contaminant mobile and able to be displaced by train wheels. Instead, the moisture levels in the Norwich area during the two days before the incident were consistent with previously damp leaves adhering to rails and then drying to form a film of electrically insulating contamination (figure 12).

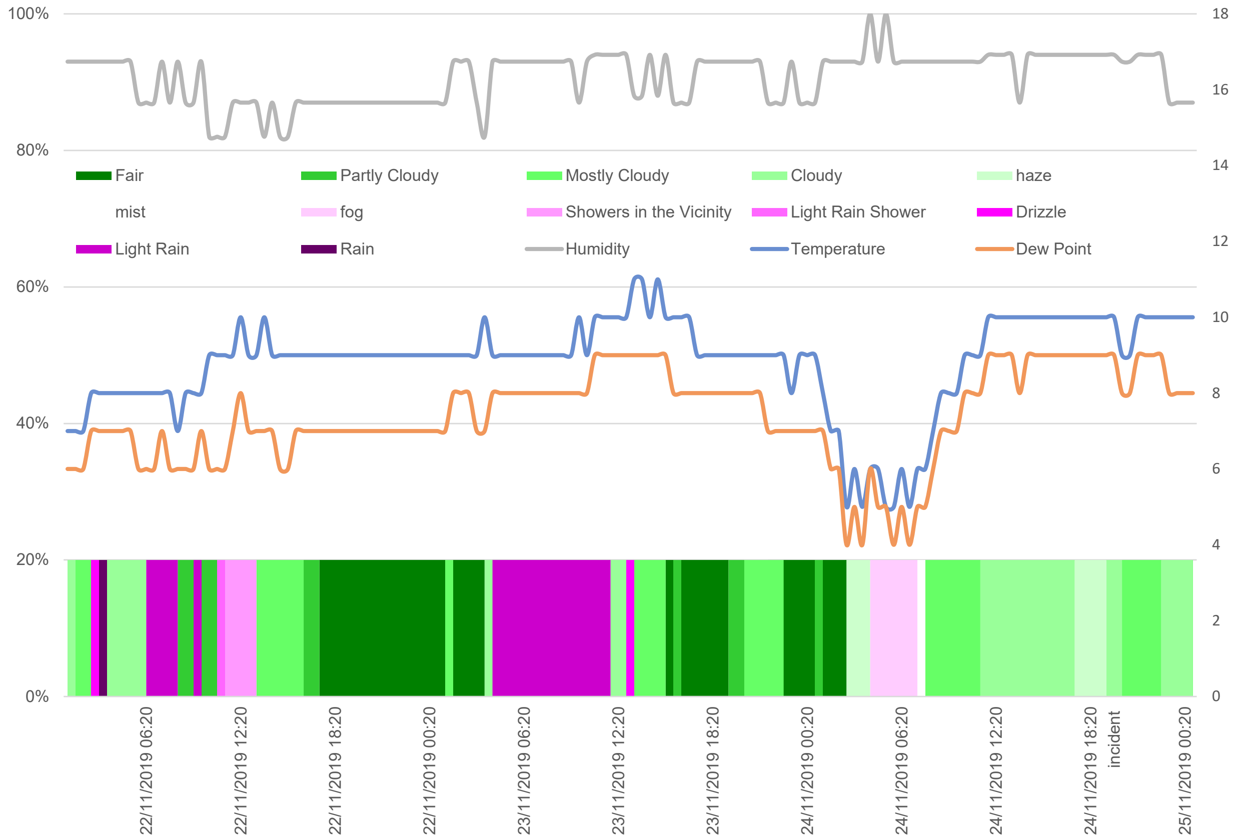

Figure 12: Temperature, dew point and humidity in the 48 hours prior to the incident, taken at Norwich airport, around 6.5 km (4 miles) from Norwich Road level crossing

The railhead cleaning regime

80 The railhead contamination was able to build up prior to the incident because no RHTTs were booked to run on this line at weekends. The last RHTT on the down line passed Norwich Road crossing at around 10:30 hrs on Friday 22 November 2019, around 57 hours before the incident.

81 Since 2016, a RHTT has run a return trip to Cromer on weekday mornings during the leaf-fall season. This was a modification of an existing weekday RHTT run on other parts of the route. Network Rail was not able to provide a record of any decision which would explain why this train ran only on weekdays, but states it may have been due to reduced availability of machines and/or operators. The scheduling of RHTTs is reviewed before each autumn, and the 2019 review had not identified a need for an enhanced treatment schedule.

82 Network Rail Anglia route staff responsible for the seasonal railhead treatment regime stated that, although they did not follow a defined process for planning the schedules of RHTT, they consider the following factors when adjusting the RHTT schedules in preparation for each autumn:

- historical safety incidents such as wrong-side track circuit failures, station overruns and reports of low rail adhesion
- whether the area includes known low rail adhesion or high-risk wrong-side track circuit failure sites
- performance data - adhesion related delay minutes
- driver feedback
- wheel slip protection data provided by train operators from OTDR analysis
- feasibility of finding an actual compliant train path
- extent of lineside vegetation
- whether there is leaf-fall team coverage.

83 Changes to schedules are considered each year at the post-season review with train operators.

84 The Network Rail standards NR/L2/OPS/095 'High Risk Sites for Wrong Side Track Circuit Failures in Leaf Fall Areas and for Low Rail Adhesion'[6] and NR/L3/OPS/021/01 'Autumn Management'[7] contain details of how to assess the risks of low adhesion and track circuit failures caused by railhead contamination. These are similar to the methods used by the Anglia route, but do not make reference to the introduction of new trains or consideration of the effect of service frequency on contamination build-up.

85 There was a narrow running band on the railhead, caused by the majority of rolling stock on the Norwich to Sheringham line being new and in similar condition.

86 On 9 December 2019, RAIB measured the wheel profiles of the train involved in the incident (755416), another class 755 unit, and one of the class 153 units that were being withdrawn from the Cromer branch at the time of the incident.

87 The class 755 trains are specified with a wheel tread profile defined in BS EN13715[8] as an EPS profile. This tread profile is equivalent to the British P8 profile, with a minor difference in the flange design. The class 153 was specified with wheel treads to the P8 profile.

88 The profiles measured by RAIB on both class 755 trains were to the design specification and all the wheels were in good, unworn condition.

89 The wheels on the class 153 unit measured by RAIB were worn, but were still within the limits permitted by the Rail Industry Standard for Wheelsets (RIS-2766-RST).

[6] NR/L2/OPS/095 'High Risk Sites for Wrong Side Track Circuit Failures in Leaf Fall Areas and for Low Rail Adhesion', issue 6, 07 September 2019.

[7] NR/L3/OPS/021/01 'Autumn Management' issue 1, 07 September 2019.

[8] BS EN 13715:2006+A1:2010 Railway applications - Wheelsets and bogies - Wheels - Tread profile.

90 RAIB also measured the profile of the railhead at several locations on the approach to Norwich Road crossing. The rails were dated 1958, and although no profile markings were visible, the dimensions of the rails correspond to the BS98N flat-bottom rail profile. The rails were worn with a noticeable asymmetry but were within the specification for serviceable rail.

91 When the profiles of the wheels were superimposed on the railhead profiles, taking account of the actual gauge of the straight track on the approach to Norwich Road crossing, RAIB observed that:

- The new class 755 units would ride on a band around 4 mm wide near the centre of the railhead if the wheelset was centred on the track, as would be expected on the straight track in this area. If the wheelset were making flange contact with either rail, there would be two narrow contact points, to the inside of the centre of the railhead and at the bottom of the running edge (figure 13).
- The worn class 153 wheelset would ride on a band around 16 mm wide from the centre to the outside of the railhead if the wheelset was centred on the track, and would make contact across most of the railhead surface from the running edge outwards if in flange contact.

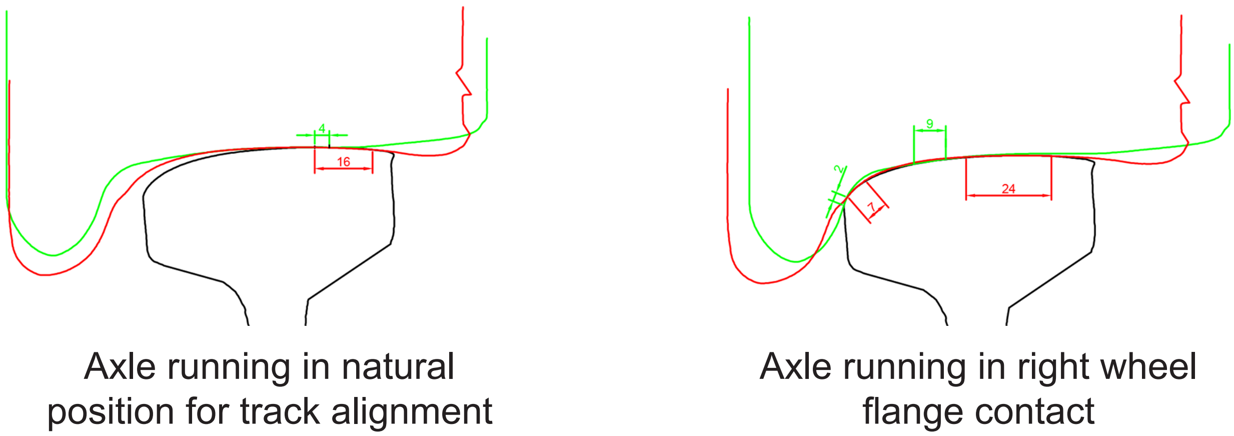

Figure 13: Outlines of the class 755 (green) and class 153 (red) wheel on the rail profile on approach to Norwich Road crossing

92 The photographs taken by Network Rail on the night of the incident show a narrow clear metal running band on the railhead consistent with the contact patch observed for class 755 trains (paragraph 91), and there was also a partially clean area consistent with class 153 and other older stock running (figure 14). The area to the inside of the centre of the railhead shows heavy contamination.

93 A narrow contact patch at the wheel-rail interface results in a relatively high pressure on the railhead, and so should result in good electrical contact if there are no insulating products present.

94 However, if a train is running on a narrow contact patch, only a small contaminated area of railhead can impede electrical connection. It is also the case that even if a good electrical contact is being made on a narrow running band, small, expected, lateral movements by the train's wheels will generally result in the contact patch moving onto adjacent contaminated parts of the railhead. Even though the class 755 trains had more wheelsets than units previously using the line, this does not appear to have improved the electrical contact.

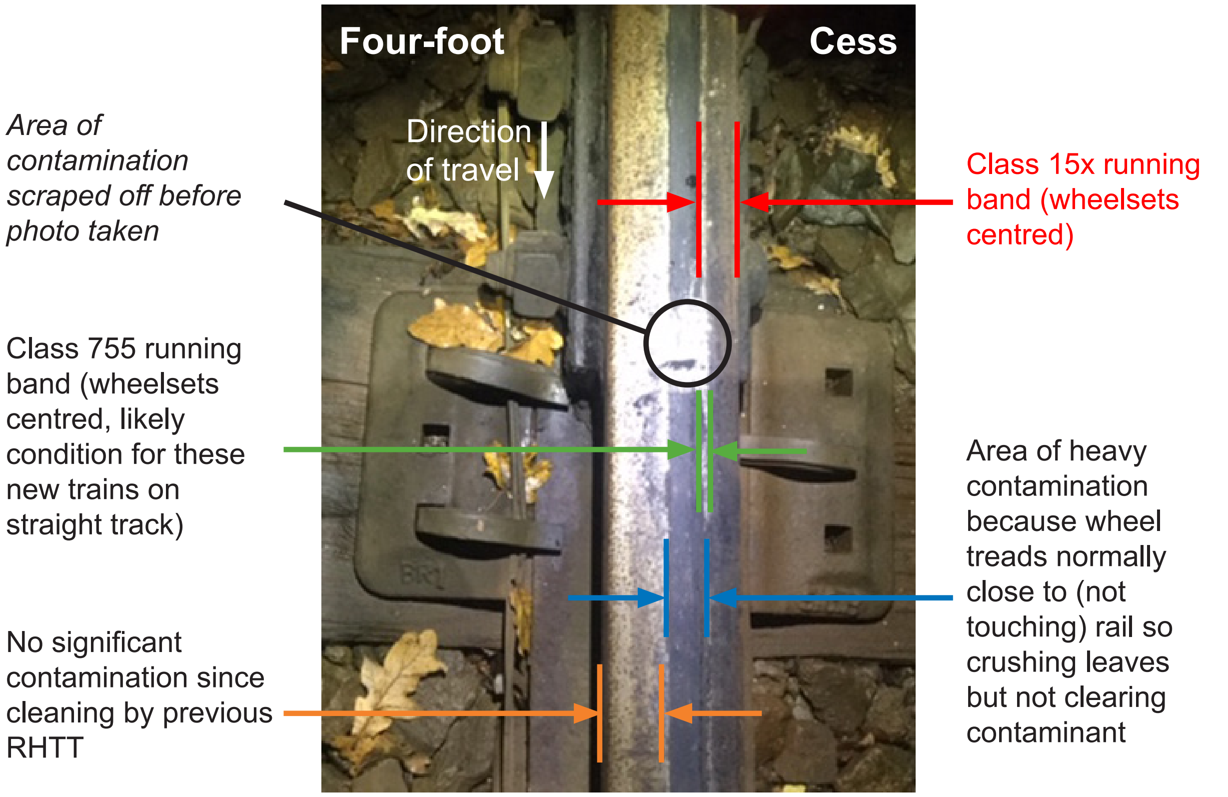

Figure 14: Railhead on the night of the incident with positions of contact patches for class 755 and other stock

95 Class 755 trains had operated track circuits and predictors without reports of incorrect operation of the crossing during the first part of the leaf-fall season. Network Rail Anglia reports that there had been fewer seasonal adhesion issues (an indication of contaminated railheads) during October and November 2019 than in typical previous years. In the four years prior to 2019, between 63% and 100% of incidents had occurred by 24 November. In 2019 only 15% did so, possibly due to late leaf-fall because of a wet summer.

96 Train 2S60 was the twelfth service to use the down line on 24 November. All except one of the previous down line trains on the day of the incident were operated by class 755 units; the exception was a class 153 (a single car four-axle unit) just over 3 hours before the incident.

97 The lack of variety in the wear of the wheelsets of the trains that had run over the line in the hours and days leading up to the incident meant that there was no opportunity to clear a wider section of the railhead of contamination.

98 The fleet of units that were operating before the introduction of class 755s had wheels that had run a variety of mileages, and therefore were in different states of wear, which would have led to a wider clean running area on the track. It is also likely that the newer design and factory condition suspension on the class 755 units resulted in the wheels on these units being less prone to lateral movements than older trains, thus leading to the new trains repeatedly running on the same part of the rail at each location.

99 The narrow running band on the railhead was an unforeseen consequence of rapidly replacing almost all the trains with new rolling stock, which left the rails vulnerable to poor electrical contact in the event of contamination.

Design of the predictor system as installed

100 The level crossing control system made insufficient allowance for incorrect operation of the train detection system.

101 At the time of the incident, the predictor system relied on the correct operation of one unreinforced track circuit with the crossing closure sequence ending if the HXP3 predictor ceased to identify, for 16 seconds or more, that a train was approaching (paragraph 45).

102 At the time the level crossing control system was installed, the relevant standard in use by Railtrack[9] was 'Principles of Control for Automatic Half Barrier Crossings & Automatic Open Crossings – Remotely Monitored' dated August 1985. At that time there was no mandated reset timer, but the standard states that where one is provided it should be set to 120 seconds. This timer, when provided, had the principal purpose of raising the barriers when a track circuit remained occupied after the passage of a train, although it would also allow the barriers to rise if a train stopped on the approach to a crossing.

103 The Network Rail signalling design handbook for automatic level crossings,[10] introduced in September 2011, requires that '*in the event that a strike-in track section becomes occupied (thus initiating the operating sequence) and subsequently clears with no train present, or the strike-in track section is not correctly reset following passage of a train, the crossing operating sequence shall be reset after a period of time, nominally three minutes*'.

104 The sixteen-second setting of the LOS timer at Norwich Road was the default value for the equipment as supplied by the manufacturer. This setting was adjustable to any value between 4 and 99 seconds.

105 The setting of the LOS timer on the HXP3 equipped crossings on the Norwich to Cromer lines was not in line with the reset principles in use on traditional relay-based AHBs, either at the time of the design or the time of the incident.

106 Network Rail has been unable to provide details of the decision process for the timer setting on the Norwich to Cromer 2000 pilot predictor project, but has provided records that indicate that the crossings on the Bedford to Bletchley re-signalling project (commissioned in 2004) were originally designed with 16 second LOS timers, but that the design was changed to 99 seconds, the maximum available and therefore the closest to the 120 second requirement, during pre-commissioning testing, which checks that the design complies with current signalling principles. It is not known whether the settings of the Norwich to Cromer level crossings were reviewed after this change was made. A subsequent installation at Thorpe Road, near Doncaster, was designed with the LOS timer set to 99 seconds.

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[9] Railtrack, a private company, owned and managed the railway infrastructure in Great Britain from privatisation in 1996 until its assets were transferred to Network Rail in 2002.

[10] NR/L2/SIG/11201/MODX10 ISSUE 1 section 6.1.2.

Factors considered that were not causal to the incident

107 Class 755 trains, in common with all non-electric multiple units on the British rail network, are fitted with TCAs. These are fitted to the second and fifth bogies of class 755 trains and help to provide a current path between the wheels on the fitted bogie by using high-frequency electric currents to raise the effective track circuit rail-to-rail voltage at the wheelsets either side of the TCA. The resultant relatively high voltage at the wheel-rail interface is intended to break down an insulating effect of rust film.

108 The TCA on the incident train was recorded by the OTDR as functioning at the time of the incident, and post-incident testing found that the TCA was inducing the correct voltage in the rails below it.

109 The train's TCA was not able to overcome the high wheel-rail resistance on the highly contaminated approach to the crossing, but it was not designed to do so. The applicable standard[11] states that: '*the assistance it* [the TCA] *provides is interrupted as the assisted wheelsets pass over an insulated rail joint or insulating railhead contamination such as a heavy deposit of dry leaf film'*.

110 British Rail research,[12] followed by RSSB research T546[13] found that some trains are more prone to attracting leaves to the wheel-rail interface than others, due to the aerodynamic design of the front, side and underframe of the train. RAIB commissioned the Wolfson Unit at Southampton University, which had undertaken previous research on behalf of the railway industry, to undertake a qualitative analysis of the aerodynamics of the front, sides and underbody of the class 755, particularly in relation to the previous stock that had operated on the Cromer branch.

111 The Wolfson Unit report concluded that based on the information currently available, the class 755 trains should have better aerodynamic performance (that is, it should produce less railhead contamination) than the class 156 for a train of the same number of axles and travelling at the same speed. The 50% increase in the number of axles compared to previous classes of train would reduce the effect of this improved performance, but it was not expected to make the Class 755 contribute significantly more to railhead contamination.

Identification of underlying factors

Predictor approval

112 Processes intended to update trial installations of equipment did not result in recognition and correction of shortcomings at Norwich Road level crossing.

113 When a new component or system is first introduced to the railway, it must undergo a process known as type approval which, if successful, will result in its manufacturer or sponsor being issued with a full product acceptance certificate.

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[11] Railway Group Standard GMRT2477 Compatibility Requirements for Track Circuit Assisters (TCAs) on Rail Vehicles, issue 3, June 2018.

[12] British Rail Research, A comparative study of the trapping of leaves by different multiple units, ref TM WRI 5, March 1982.

[13] T546, RSSB research programme, Engineering, Understanding aerodynamic influences of vehicle design on wheel/rail leaf contamination, July 2006.

114 With more complex systems, such as the HXP3 level crossing predictor, it is often necessary to undertake, after initial testing, one or more trial installations on the railway to demonstrate the functioning and reliability of the system. This is known as a pilot installation, and is authorised by a limited form of approval which is documented on a certificate of authority for a pilot installation. This certificate will include the locations in which the product can be installed and any special conditions relating to the installation(s).

115 If a pilot is successful, the trial may be extended to other locations, or a full product acceptance certificate issued. If it is unsuccessful, the product must be removed from the railway.

116 At the time the level crossing predictors were installed on the Norwich to Cromer line as a pilot installation (paragraph 38), and then on the Bedford to Bletchley line, as a trial installation, the relevant Railtrack procedure[14] did not contain any guidance for the process for updating the trial certificate if modifications were needed to a system during the trial period.

117 The current standard that relates to product approvals[15] requires that, should a modification to the system be required, the trial certificates must be updated and therefore all installations of the trial system would need to comply with the modification. In the case of the incident, the Cromer branch pilot installation would have been required, by an amendment to the approval certificate, to have the LOS timer settings increased to match those approved on the later Bedford to Bletchley trial installation.

118 The Norwich to Cromer HXP3 installations were granted a full product approval certificate on 17 November 2004, which also approved the HXP3 for trial use on the Bedford to Bletchley line. The certificate contains the requirement that 'any proposed change to the product application (to the actual product or its configuration) shall be put forward in writing to Network Rail, HQ Acceptance Services'. This requirement was also on the final version of the certificate of authority for a pilot installation, issued on 9 August 2004 when a software change was installed. It is not known whether this requirement was on the earlier issues of the certificate, nor why the difference in the LOS timer settings between the various installations was not understood and acted upon.

119 Following experience with the pilot and trial installations, on 31 October 2008 the HXP3 predictor was accepted for use on Network Rail infrastructure for the detection of trains on the approach to automatic crossings on non-electrified lines. Amendments to the product configuration details resulted in a second issue of the acceptance certificate on 30 April 2009. These certificates made no reference to the LOS timer settings.

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[14] RT/LS/P/029 Product Acceptance, issue 1, October 1999.

[15] NR/L2/RSE/100 Module 05 Product acceptance and change to Network Rail operational infrastructure, issue 3, 3 March 2018.

Observations

120 The automatic sanders on class 755 trains included a ten second delay.

121 When the driver of the incident train applied the emergency brake (paragraph 26) the train experienced wheel slide for 190 metres, before the automatic sander applied sand to the interface between rails and some wheels (paragraph 76 and figure 10).

122 Good practice guidance provided in clause A.2.2 of Railway Group standard GMRT2461 states:

‘*Where the means of detection of low adhesion is from a wheel slide detection system, the wheel slide detection system activates the sanding equipment when any wheelset on the vehicle containing the sanding equipment suffers a significant level of slide due to low adhesion (a significant level of slide is generally recognised as a wheelset rotational speed at 95% or less than the true train speed)*’

123 It is clear that during this incident the train had encountered very significant levels of low adhesion and yet the application of sand was delayed. This delay was caused by the interface between the wheel slide prevention (WSP) sub-system and the train’s automatic sander. Although the WSP system took action to correct slide immediately, the output that Stadler used to control the automatic sander did not report slide for the first ten seconds. This delay had been included by the WSP manufacturer to avoid excessive wheel slide warnings on the train management system.

124 Stadler was unaware that this output included a delay when its designers used it to drive the automatic sander. The error had been identified before the incident, and Greater Anglia drivers briefed, but the engineering change to remove the delay had not yet been implemented on the trains.

125 At the time of the incident, with the exception of Thorpe Road, all the HXP3 predictors on Network Rail’s infrastructure relied on an unreinforced track circuit.

126 Although it was not a factor in the incident because the initial approach of the train was detected (paragraph 53), the level crossing control system did not include mitigation against a track circuit failing to detect an approaching train, potentially allowing a train to approach a crossing while it was open to road users.

127 Network Rail provides guidance on electrical circuit designs for specific applications in drawings known as typical circuits. Drawing X00030 ‘Example treadle arrangements for automatic half barrier crossings’ dated February 1999 provides guidance that each track circuit that may be used to initiate the warning sequence should be assisted by a pair of treadles. Adding treadles to a track circuit ensures that the presence of the train’s wheels will operate the associated control circuits, irrespective of whether the track circuit has detected their presence.

128 There are no typical circuits available that are specific to the HXP3 predictor. There are typical circuits for GCP3000 predictors dated September 2008, which do not specify any reinforcement of the track circuit.

129 It is likely that the designers of the predictor installations believed that the design of the predictor track circuits made it unnecessary to reinforce them, as they relied on small changes of signals rather than the on/off function of a relay.

130 On 19 October 2011 a class 67 locomotive was able to approach to within 150 metres of Cherry Holt level crossing, Lincolnshire, before the barriers lowered. The locomotive was travelling at 52 mph (83 km/h), meaning that, including the flashing road lights, road users would have had a total warning of around 10 seconds before the arrival of the train. Cherry Holt level crossing was the first installation of a GCP3000 predictor on Network Rail infrastructure. As a result of this incident, Cherry Holt crossing was fitted with treadles. There is no evidence that fitting treadles retrospectively to crossings fitted with HXP3 predictors was considered.

Previous incidents

131 RAIB investigated a number of low adhesion incidents which occurred in autumn 2005 (RAIB report 25/2006 – part 3) and concluded that the earlier that sanding is initiated, the more effective it is, and that it should be applied continuously while the WSP system is active. Recommendation 1 of this report was that train operators should ensure that multiple units fitted with sanding equipment lay sand for the duration of the period when the WSP system is active on the leading vehicle. As a consequence of this recommendation, modifications were made to a number of train types such that sand was laid once the significant levels of WSP are detected. This good practice is now recorded in clause A.2.2 of Appendix A of Railway Group standard GMRT2461.

Summary of conclusions

Immediate cause

132 The level crossing opened for road traffic as a train was approaching, allowing cars onto the crossing (paragraph 47).

Causal factors

133 The causal factors were:

a. Train detection equipment incorrectly reported the position of the approaching train because of inconsistent electrical contact at the wheel-rail interface (paragraph 52). This causal factor arose because:

   i. High levels of railhead contamination existed in the area, probably as a result of limited operation of the RHTT (paragraph 68, **Recommendation 1**).

   ii. There was a narrow running band on the railhead, caused by the majority of rolling stock on the Norwich to Sheringham line being new and in similar condition (paragraph 85, **Recommendation 2**).

b. The level crossing control system made insufficient allowance for incorrect operation of the train detection system (paragraph 100, **Recommendation 3, Learning point 2**).

Underlying factors

134 Processes intended to update trial installations of equipment did not result in recognition and correction of shortcomings at Norwich Road level crossing (paragraph 112, **Recommendation 3**).

Observations

135 Although not linked to the incident on 24 November 2019, RAIB observes that:

a. The automatic sanders on class 755 trains included a ten second delay (paragraph 120, see paragraph 139)

b. At the time of the incident, with the exception of Thorpe Road, all the HXP3 predictors on Network Rail's infrastructure relied on an unreinforced track circuit (paragraph 125, see paragraph 137).

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

Actions reported that address factors which otherwise would have resulted in a RAIB recommendation

136 The LOS timers on all HXP3 systems on Network Rail's infrastructure have been set to 99 seconds, the maximum available on this equipment, to guard against barriers rising before a train arrives at a crossing if the predictor incorrectly assesses its position.

137 All HXP3 predictor crossings have been fitted with pairs of reinforcement treadles. The new pairs of treadles are fitted at the equivalent of the strike-in point, the point at which the minimum warning time for the road user is achieved with the fastest train. The treadles will force the crossing sequence to start if the predictor has not registered the train while it was running between the limit of approach and the treadles. If the HXP3 predictor has registered the train before it reaches the treadles but not started the sequence due to the train's speed, the treadles will have no effect.

138 The current signalling design handbook for level crossings[16] includes the need for the reinforcement of track circuit strike-ins with treadles, or the use of axle counter-based train detection.

139 The automatic sander operation on all Stadler manufactured Greater Anglia trains (class 755 and 745 units) has had the delay removed (paragraph 124). This knowledge has been shared with other current and future projects supplying trains to the British railway network, the only market currently using automatic sanders on Stadler trains.

140 Network Rail is currently developing remote condition monitoring systems for signalling and level crossing equipment. This should result in data on the real-time performance of level crossings becoming available to maintenance staff and investigators, should they need it.

Other reported actions

141 The frequency and pressure of scrubber block applications has been increased on class 745 and 755 trains. These blocks, which are similar to small tread brakes, are intended to improve traction by cleaning the treads of the driven wheels. Although it is not the design intent of the scrubber blocks, it is possible that their increased usage will provide some improvement to the wheel-rail electrical contact.

[16] NR/L2/SIG/11201/ Mod X02, Level 2, Signalling Design: Module X02 - Level Crossings: Common Design Requirements, Issue 2, 01/12/2012.

Recommendations and learning points

Recommendations

142 The following recommendations are made:[17]

1 *This recommendation recognises that experience from previous years' leaf-fall seasons is an important input to planning railhead treatment but will not take account of effects due to rolling stock changes since then.*

Network Rail should review and update its processes so that teams responsible for planning autumn railhead treatment are made aware of, and take account of, changes in rolling stock which have happened, or are expected to happen, since the start of the previous autumn and which may affect the wheel-rail interface (paragraph 133a i).

2 *The intent of this recommendation is to mitigate risk from introducing new train types which will have significantly different wheel-rail interface characteristics from the trains which they replace.*

Network Rail should provide some additional guidance to accompany the standards governing the technical compatibility between vehicles and infrastructure concerning the need for proper consideration of the risk arising from a change of the predominant wheel-rail interface on a route following the introduction of new rolling stock over a short period of time. This consideration should include wheel-rail interface characteristics which are compliant with relevant standards but which differ from rolling stock used previously (paragraph 133a ii).

3 *The intent of this recommendation is to ensure that lessons learnt during successive installations of a signalling system are applied to earlier installations where necessary.*

Network Rail should review and enhance its processes for managing the configuration of signalling equipment so that earlier installations are modified where necessary to reflect safety improvements implemented on later installations (paragraph 134).

[17] 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 and Road to enable it to carry out its duties under regulation 12(2) to:

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

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

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

Learning points

143 RAIB has identified the following learning points:[18]

1 It is important that Network Rail staff who believe, or suspect, that railhead contamination has caused a wrong-side failure of signalling or level crossing equipment always take and preserve contamination samples so that a sample is available for analysis if required.

2 This incident highlights the need for signalling designers and approvers to identify, and provide a documented justification for, any variations from standards and typical designs.

[18] 'Learning points' are intended to disseminate safety learning that is not covered by a recommendation. They are included in a report when RAIB wishes to reinforce the importance of compliance with existing safety arrangements (where RAIB has not identified management issues that justify a recommendation) and the consequences of failing to do so. They also record good practice and actions already taken by industry bodies that may have a wider application.

Appendices

Appendix A - Glossary of abbreviations and acronyms

AHB	Automatic half barrier
FFCCTV	Forward facing closed-circuit television
GCP3000	A type of level crossing predictor manufactured by Westinghouse Rail (now Siemens)
GSM-R	Global System for Mobile Communications - Railways
HXP3	A type of level crossing predictor manufactured by Vaughan Harmon (now Alstom)
LOS	Loss of shunt
mΩ	Milli Ohm, 1/1000th of an Ohm
OTDR	On-train data recorder
RAIB	Rail Accident Investigation Branch
RHTT	Rail head treatment train
RSSB	Rail Safety and Standards Board
TCA	Track circuit assister
V	Volt
WSP	Wheel slide protection

Appendix B - Investigation details

RAIB used the following sources of evidence in this investigation:

- train FFCCTV and data recorder
- signalling data recorder
- Railway Group and company standards
- approval documentation
- design documents and user manuals
- historic records
- testing data
- statements from witnesses
- specialist reports commissioned by industry
- specialist reports commissioned by RAIB
- a review of previous RAIB investigations that had relevance to this incident.

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