Rail Accident Investigation Branch

Rail Accident Report

Freight train derailment at Eastleigh, Hampshire
28 January 2020

Report 02/2021
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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
- the Railways (Accident Investigation and Reporting) Regulations 2005.

Any enquiries about this publication should be sent to:

RAIB
The Wharf
Stores Road
Derby UK
DE21 4BA

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

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Preface

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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.

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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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Summary

At about 11:32 hrs on Tuesday 28 January 2020, a freight train derailed while travelling over a set of points at Eastleigh West Junction, immediately south of Eastleigh station. The locomotive hauling the train ran derailed for about 35 metres, causing significant damage to the infrastructure. Four wagons subsequently derailed on the damaged track. Nobody was injured in the accident.

Some of the fastenings that hold the rails to the concrete bearers that support them had fractured, prior to the passage of the train. This allowed one of the rails to move outwards under the train, breaking further fastenings and causing the locomotive's wheels to drop inside the rail, as it moved further outwards. The design of these fastenings made them more prone to this type of failure when subjected to high lateral forces, which were present at these points due to the track geometry at the site and the curving characteristics of the locomotive. The local track maintenance team had not identified any relevant faults prior to the derailment as the fastenings had fractured below the surface of the concrete bearer and these failures were not apparent during visual inspections. Despite previous faults of a similar nature elsewhere, Network Rail had not developed an effective inspection regime to detect such failures. Measurements of the track geometry of this set of points had also not detected any indication of deterioration in the track fastening system.

RAIB also observed that the maintenance delivery unit at Eastleigh was not effectively managing the maintenance of its track assets, and that evidence identified for preservation as part of this accident investigation was lost during the track repair work undertaken by Network Rail after the derailment.

RAIB has identified two recommendations and two learning points as a result of the investigation. The recommendations are both addressed to Network Rail. The first regards the development of a management strategy to address the ongoing risk of failure of track fastening systems of the type involved in the derailment. The second concerns a review of how Network Rail measures dynamic track gauge on lines that are not monitored by a track measurement train.

The first learning point concerns the importance of ensuring the correct cause of engineering failures is identified, and that subsequent actions are taken to control the associated risks. The second learning point reminds rail industry bodies of the importance of preserving evidence for safety investigations, and their legal duty to do so.

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 and acronyms. These are explained in Appendix A. Sources of evidence used in the investigation are listed in Appendix B.

The accident

Summary of the accident

3 At around 11:32 hrs on 28 January 2020, the locomotive hauling a freight train travelling from Birch Coppice to Southampton docks, derailed at a set of points at Eastleigh West Junction, immediately south of Eastleigh station, Hampshire (figure 1). The locomotive was travelling at 12 mph (19 km/h) when it derailed.

4 The derailment occurred because the rails moved apart under the locomotive as it passed over the points. This eventually caused the locomotive's wheels to drop between the rails. The driver applied the emergency brake when she felt the locomotive begin to shake during the derailment. The locomotive ran derailed for approximately 35 metres, causing further damage to the track, before it re-railed itself at another set of points. Four of the wagons in the train derailed on the portion of track that had been damaged by the derailed locomotive.

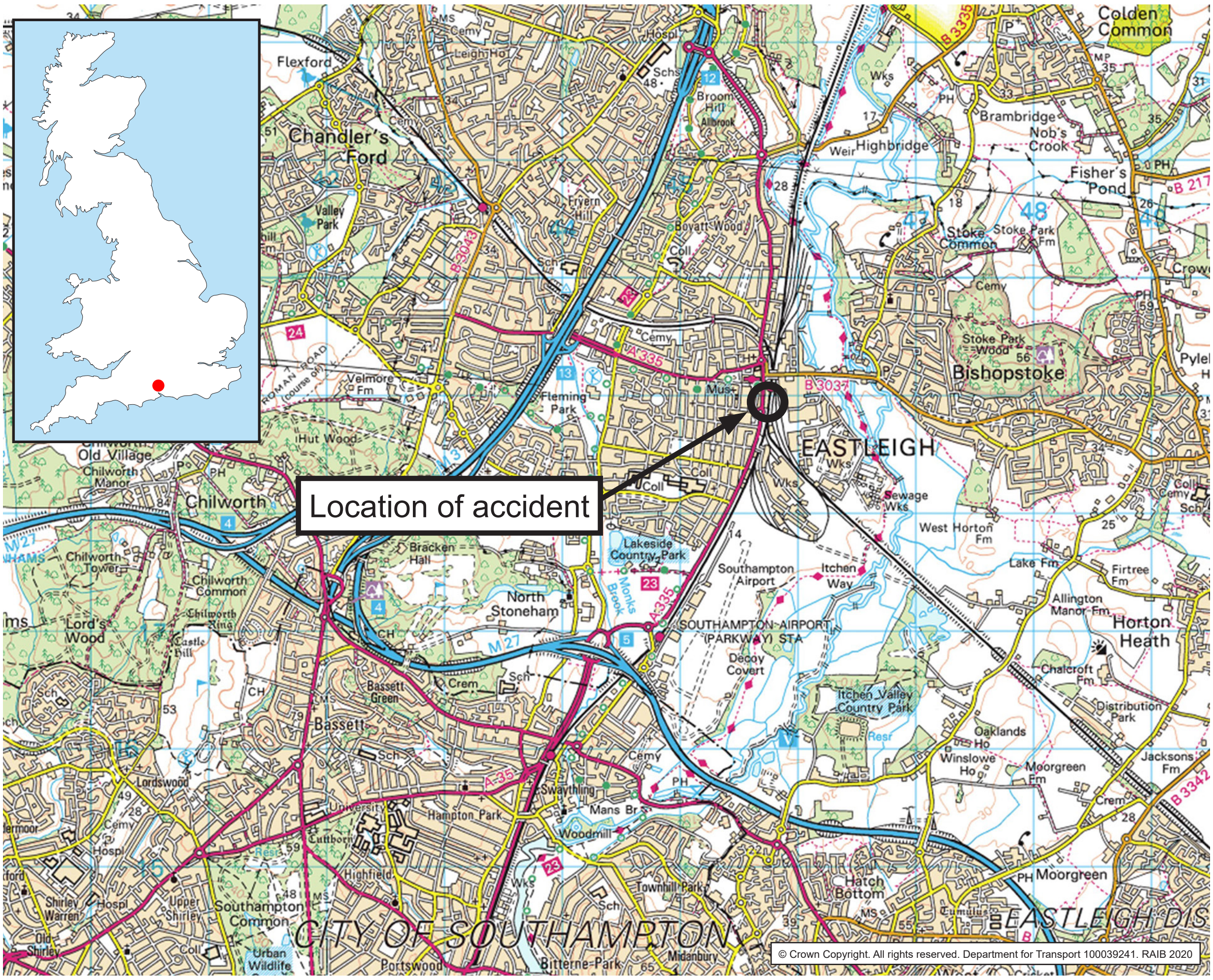
Location of accident

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

5 Significant damage was caused to the points at Eastleigh West Junction. The recovery of the train and infrastructure repairs caused the line to be closed for five days, and resulted in disruption to services for several weeks. The train suffered minor damage. Nobody was injured in the accident, although one member of infrastructure maintenance staff was almost struck by flying debris.

Figure 2: The derailed wagons following the accident

Context

Location

6 Eastleigh West Junction is located at 73 miles and 42 chains[1] from London Waterloo station on the South Western main line, which runs between Waterloo and Weymouth on Network Rail's Wessex route. As well as seeing a high volume of passenger services, the lines through Eastleigh station carry a significant amount of freight traffic to and from Southampton docks.

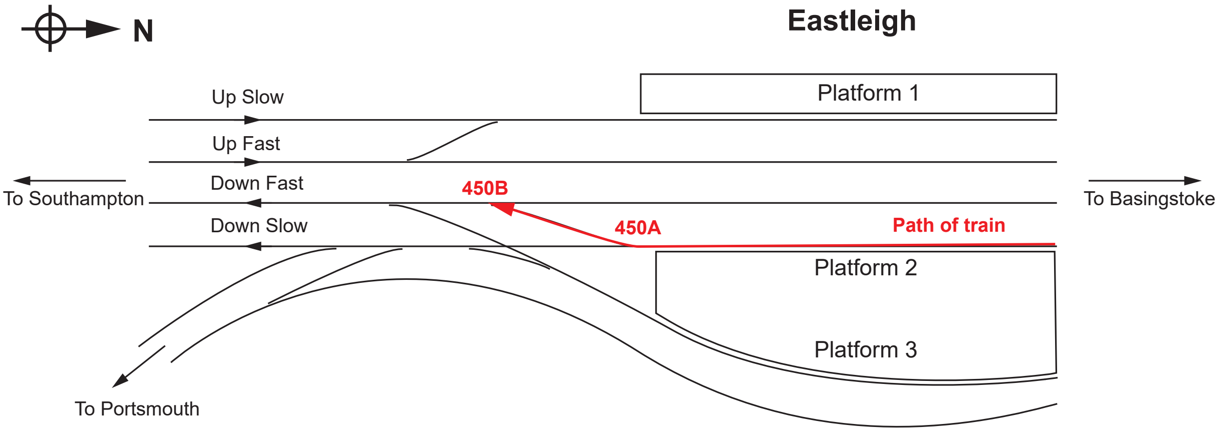

Figure 3: Track layout at Eastleigh station

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[1] A unit of length equal to 22 yards (20 metres). There are 80 chains in one mile.

7 The derailment occurred at the south end of Eastleigh station platform 2, as the train traversed 450A points. These form part of a crossover[2] with 450B points. At the time of the accident, both 450A and 450B points were set for trains to travel from the down slow line to the down fast line (figure 3). The maximum permitted speed for trains to pass over the crossover is 15 mph (24 km/h).

8 Although the railway is level and generally straight at this location, trains need to negotiate tight radius curves when travelling over the crossover.

Organisations involved

9 Network Rail owns and maintains the track on which the derailment occurred. It employs:

- the Wessex (outer) infrastructure maintenance engineer (IME)
- the Eastleigh infrastructure maintenance engineer [track] (IME[T])
- the Eastleigh track maintenance engineer (TME)
- the Eastleigh section manager [track] (SM[T])
- the other track maintenance staff at Eastleigh.

10 Freightliner operated the train and owns the locomotive which derailed. It also employs the driver of the train.

11 VTG Rail UK Ltd owns and maintains the container wagons which formed the train.

12 Balfour Beatty Railway Engineering (BBRE) designed and manufactured the crossover. Progress Rail, part of the Caterpillar Group, acquired some of the relevant assets of BBRE from Balfour Beatty in 2011.

13 All these organisations freely co-operated with the investigation.

Train involved

14 Train reporting number[3] 4O05 was hauled by locomotive 70001, a class 70 diesel-electric locomotive. A class 70 locomotive weighs between 129 and 135 tonnes, depending on the volume of fuel it is carrying. It has two bogies, each with three powered axles.

15 The locomotive was hauling 30 FWA type container wagons. Fifteen of these wagons were carrying a mixture of empty and loaded shipping containers. The total train weight was reported as 1,171 tonnes.

16 Prior to arriving at Eastleigh, the train passed two GOTCHA[4] sites, one at Cholsey and the other at Shawford. These sites recorded the distribution of weight between the train's wheels. The data from these sites showed that the train's loading was within allowable tolerances, and that there was no significant lateral or longitudinal asymmetric weight distribution on the locomotive or wagons.

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[2] A track arrangement that allows trains to change from one line to an adjacent line.

[3] An alphanumeric code, known as the 'train reporting number', is allocated to every train operating on Network Rail infrastructure.

[4] This is the tradename of a type of detector that measures wheel loads. Its primary purpose is to detect high impacts caused by damaged wheels. However, the system also records information about the distribution of weight between wheels.

Staff involved

17 The driver of the train had taken it over from the previous driver at 11:30 hrs, at Eastleigh station, immediately prior to the accident occurring.

18 Two infrastructure maintenance staff were near the points at the time of the derailment. Both worked for the track maintenance department at Network Rail's Eastleigh Maintenance Delivery Unit (MDU). This unit is part of the maintenance organisation of Network Rail's Wessex route.

External circumstances

19 It was daylight at the time of the accident. The local weather as seen on closed-circuit television (CCTV), and as reported by staff on site, was fair and cold. There is no evidence to suggest that external circumstances were a factor in the derailment.

The sequence of events

Events preceding the accident

20 At 07:13 hrs on 28 January 2020, train 4O05 departed from Birch Coppice (near Tamworth) to travel to Southampton docks.

21 At 11:20 hrs, passenger train 2S27 departed from platform 2 at Eastleigh and travelled over 450A points on the down slow line. Forward facing CCTV from this train showed that three of the fastenings that hold the rail to the concrete bearers on 450A points were missing as the train passed them (figure 4).

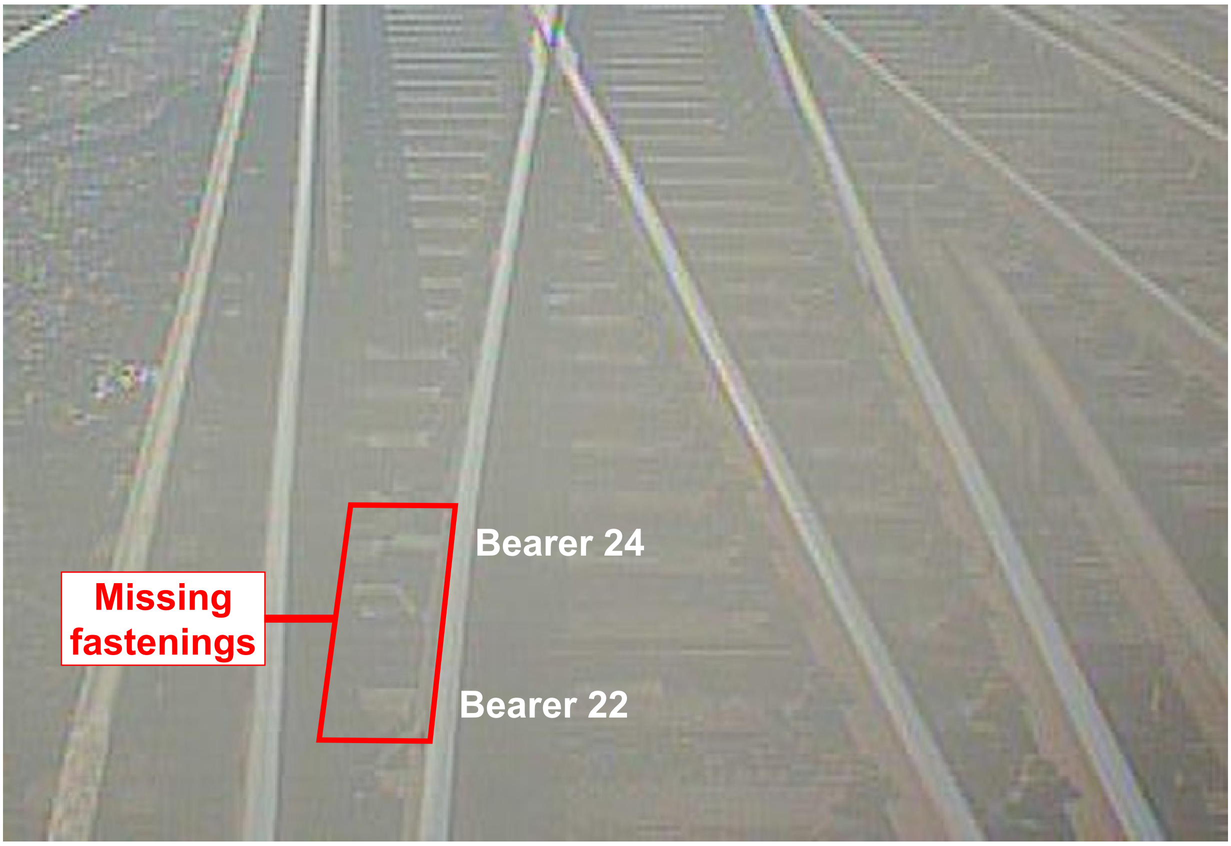

Figure 4: Forward facing CCTV from 2S27 showing three missing fastenings on bearers 22, 23 and 24 (image courtesy of South Western Railway)

22 Train 4O05 approached Eastleigh on the down fast line, before it crossed to the down slow line and stopped at platform 2 at around 11:28 hrs. When it arrived in the platform, the train was taken over by a new driver (paragraph 17).

23 While train 4O05 was in the platform, two Network Rail infrastructure maintenance staff were undertaking an inspection of track joints between 450A points and platform 2 of Eastleigh station. Although their planned work did not include an inspection of 450A points, they noticed that "*about three*" fastenings were missing. They did not have time to inspect the points more closely because the subsequent approach of train 4O05 meant that they needed to move to a position of safety.

Events during the accident

24 At 11:31 hrs, train 4O05 began to move out of platform 2. The driver saw the two infrastructure maintenance staff ahead of the train and sounded the locomotive's horn as a warning. The staff saw the approaching train and moved into the wide space between the down slow line and an adjacent line, so that they were standing clear of the track.

25 The train had reached 12 mph (19 km/h) as it arrived at the crossover. The front bogie of the locomotive passed over the switch rails[5] (figure 5) of 450A points without incident. As the locomotive passed over the closure rails,[6] the lateral forces it exerted (see paragraph 78) caused the rails to spread apart, and the failure of additional fastenings (figure 5). This caused all of the locomotive's wheels to drop into the now-widened gap between the rails and to derail. One of the fastenings flew out as it failed and almost struck one of the infrastructure maintenance staff.

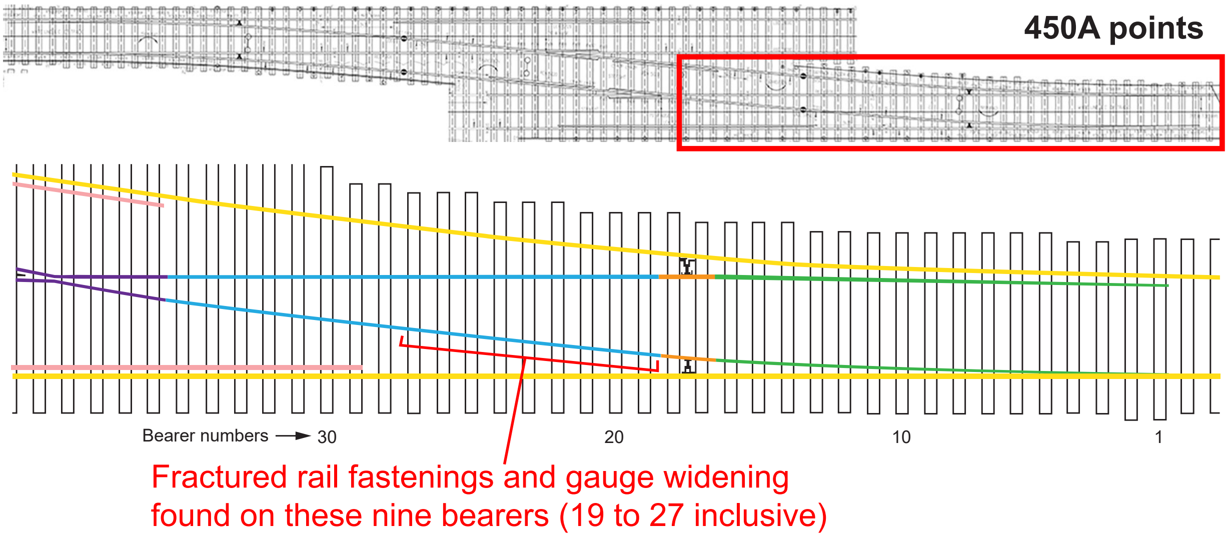

Figure 5: Overview of crossover formed by 450A and 450B points and (below) 450A points showing the switch rails (green), stock rails (yellow), check rails (pink), switch heel on baseplates (orange), closure rails on cast iron wedges (blue) and crossing on baseplates (purple).

26 The locomotive continued to run derailed, causing damage to the track, before rerailing itself while traversing 450B points as it reached the down fast line (figure 6). The first three wagons and the fifth wagon of the train derailed on the section of track damaged by the locomotive. This caused further damage to the track.

27 The driver felt the train lurch as it passed over 450A points and made an emergency brake application. The train subsequently stopped with the locomotive around 90 metres beyond the point of derailment.

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[5] The movable machined section of rail that forms part of a switch assembly. This and other definitions marked with an asterisk have been taken from 'Ellis's British Railway Engineering Encyclopaedia' © Iain Ellis http://iainellis.com/

[6] The rail between the switch rail and common crossing.*

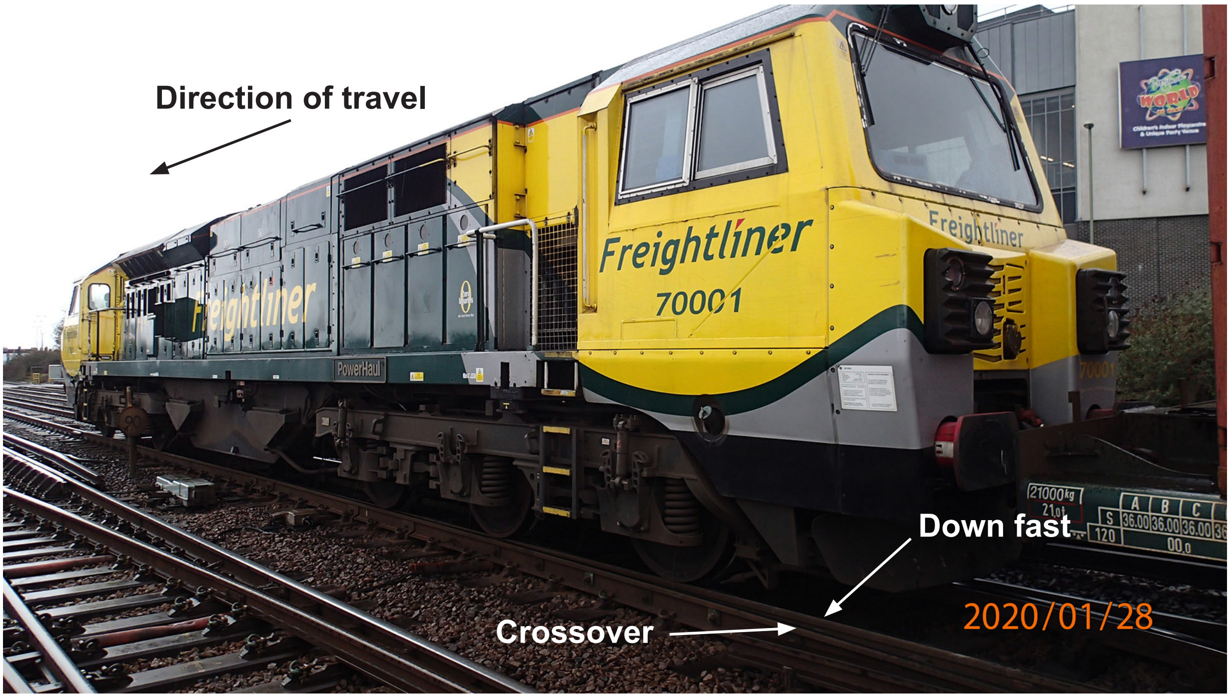

Figure 6: The locomotive following the derailment showing its final position with the rear bogie on the down fast

Events following the accident

28 Following the accident, the driver of train 4O05 made an emergency call to the signaller, requesting that all train movements on adjacent lines were stopped.

29 The recovery of the derailed train and repairs to the infrastructure caused the lines at Eastleigh to be closed for five days following the accident. The crossover was reinstated over the next four weeks and there was significant disruption to rail services during this time.

Background information

Design of switches and crossings

30 Track junctions allow trains to be directed along different routes, and for railway lines to cross one another. Junctions consist of various individual components including switches and crossings (S&C).[7] Switches are the moving rails that direct a train down one route or another, while crossings are the fixed elements that allow one rail to cross another (figure 5).

31 Rails are supported by transverse beams known as sleepers or bearers. Sleepers support two rails, while bearers, which are usually of a larger cross-section, support more than two rails and are used in components such as S&C. A track fastening system is used to attach the rails to the sleepers or bearers. Most of the mainline rail network in Great Britain uses a fastening system based on the use of sprung steel 'clips'. These clips are inserted into cast iron shoulders which are in turn fixed to the bearer or sleeper. Each clip is then pulled over the foot of the rail. This deflects the end of the clip and applies a load which holds the rail in place. This 'toe load' varies from 6.5 kilonewtons (about 650 kg force) to 12.5 kilonewtons (about 1250 kg force) depending on the design of the fastening system. As well as clips and shoulders, track fastenings also include ancillary components, normally made of plastic or rubber, to provide resilience and electrical isolation. These ancillary components can also act as sacrificial wear pieces to protect the bottom of the rails.

32 The S&C forming 450A points, and much of the remainder of the layout at Eastleigh West Junction was an 'RT60' type layout, designed and manufactured by BBRE in around 2001. RT60 layouts were produced after Railtrack, then the owners of the infrastructure, approached manufacturers of S&C to produce layouts that would allow for increased axle loads, higher junction speeds and improved robustness.

33 The Railtrack technical specification for these layouts asked for criteria to be met including:

a. use of the heavier duty CEN60E1 rail section

b. the ability to carry up to 30 tonne axle loads

c. maintenance of a 1 in 20 rail inclination[8] through the layout

d. a constant level at the bottom of the bearers, to aid installation and assembly

e. use of non-threaded fastenings in the concrete bearers

f. specific requirements for track stiffness.

34 Four manufacturers proposed different solutions which met this specification to varying degrees. These four designs were all broadly similar, but with minor differences.

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[7] Throughout the report the term 'switches and crossings' (S&C) is used to describe all means of intersection of railway lines. The term 'points' is used when specific reference is made to parts of Eastleigh West Junction.

[8] The rails on most track in the UK are inclined inwards from vertical at an angle of 1 in 20 (2.9 degrees). This improves the wheel-rail interface and steering capabilities of trains. In contrast, most traditional S&C units use vertical rails as it allows for simpler transitions when rails cross one another.

35 Layouts built to the BBRE RT60 design, including 450A points, use a modified track fastening system developed by BBRE to comply with this technical specification. These incorporate either the Pandrol 'Fastclip' clip or, as in the case of 450A points, high-load 'ePlus' clips which exert a nominal toe load of 12.5 kilonewtons. The modified track fastening system also uses an elevated type of cast iron shoulder.

36 There are two common methods of fixing cast iron shoulders into concrete bearers where threaded components are not permitted (paragraph 33e):

a. Casting the shoulder into the concrete during bearer manufacture. This requires the shoulder to be accurately positioned and each bearer to be individually adjusted and set up during the casting process. This method allows a direct interface between the concrete and the shoulder.

b. Casting standard bearers without shoulders in place and then drilling multiple cylindrical holes along the central axis of the bearers, to allow the shoulders to be fixed in place with an epoxy chemical grout. This allows standardised bearers to be used, but adds an extra interface, as there is now a layer of epoxy grout between the cast iron shoulder and concrete. This was the method used in the RT60 S&C design created by BBRE (see figure 7).

37 During 2005 and 2006 Network Rail standardised the design of RT60 layouts. It designated this new design 'NR60', and S&C manufacturers now work to this later standard.

Track maintenance standards

38 Network Rail track maintenance is managed using a suite of company standards, with most routine maintenance being governed by standard NR/L2/TRK/001, 'Inspection and Maintenance of Permanent Way'.[9] This standard currently includes 20 modules, each dealing with a different area of track maintenance.

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[9] Permanent Way is an alternative, historic name to describe the track system.

Analysis

Identification of the immediate cause

39 The track was unable to maintain the correct gauge as the train passed over 450A points.

A site survey undertaken by RAIB and Network Rail following the derailment found that the left-hand closure rail of 450A points had moved laterally, widening the track gauge enough so that the locomotive’s wheels were able to drop into the space between the rails and derail (paragraph 25). This survey found that a total of nine consecutive fastenings had failed along the left-hand closure rail. For comparison, module 3 of NR/L2/TRK/001 states that maintenance action must be taken where three or more consecutive fastenings are missing or ineffective.

40 An examination of the fastenings which failed showed that they had all done so via a fracture through the stem of their cast iron shoulders, at a point approximately 30 mm below the surface of the bearer (figures 7 and 8). This is one of the narrowest parts of the stem in the direction of the failure.

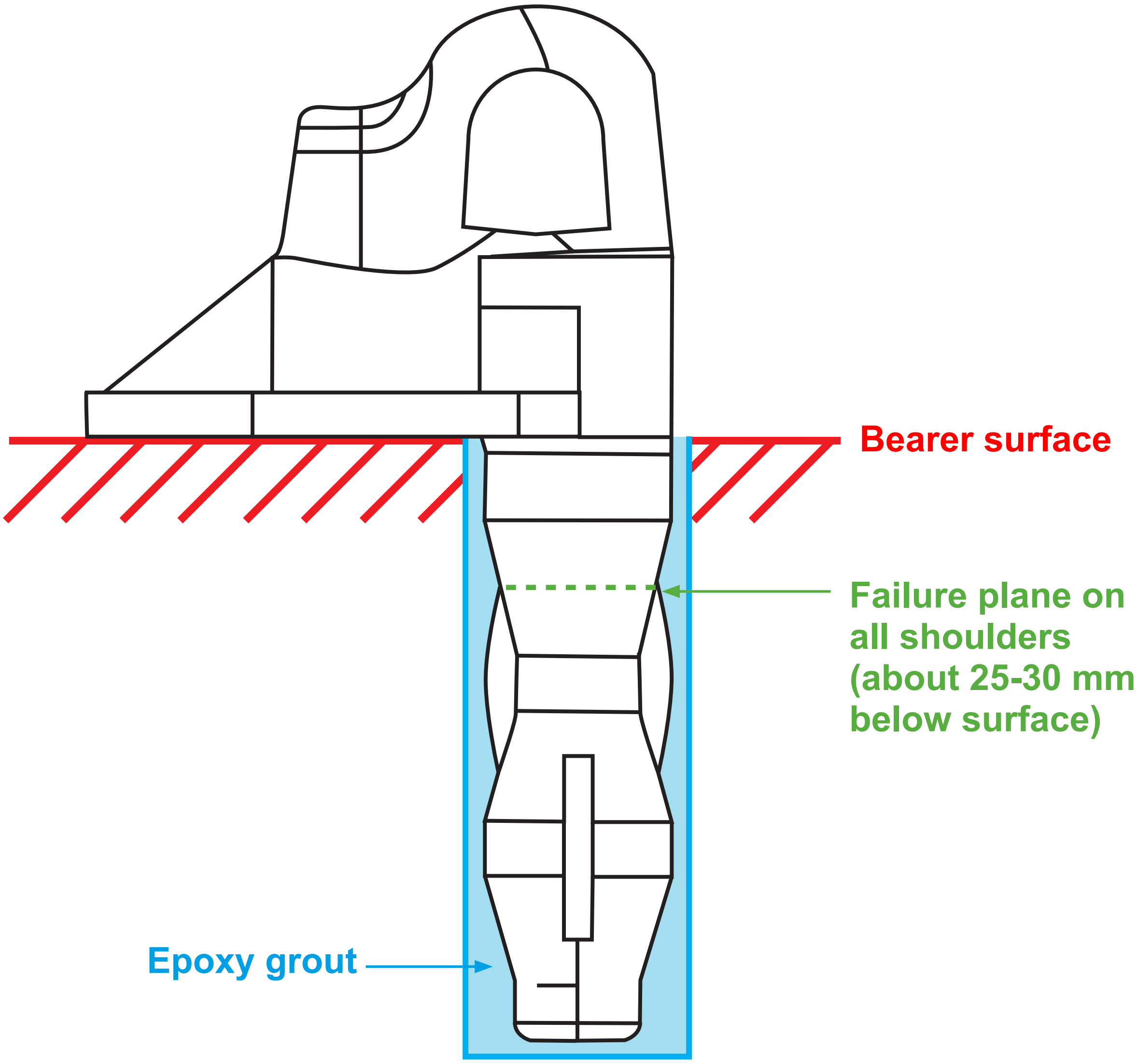

Figure 7: Profile view of a cast iron shoulder indicating the typical plane of failure in green.

Figure 8: Photograph of one of the failed cast iron shoulders

41 Forward facing CCTV from train 2S27 confirmed that three of the nine fastenings found to have failed after the accident were missing prior to the passage of train 4O05 (paragraph 23). These were the fastenings to the left-hand side of the closure rail at bearers 22, 23 and 24 (figure 9).

42 The missing shoulders from bearers 23 and 24 were recovered for further analysis, along with the six other fractured shoulders from 450A points. Four fractured shoulders which were found on the ground in the vicinity of the points were also recovered. The missing shoulder from the fastening on bearer 22 could not be positively identified due to the nature of the damage, but RAIB considers it was probably one of the four loose shoulders found near to the points, with the rest coming from other parts of the track that were damaged in the derailment.

43 An independent metallurgical inspection was commissioned by Network Rail on a sample of four of the fractured shoulders from 450A points, and the four found on the ground nearby. This inspection, combined with other analysis commissioned by Network Rail, showed that three of the shoulders from 450A points had failed in a fast-brittle manner (see paragraph 81), whereas the others had been subject to a fatigue failure (see paragraph 47). It is probable, given the failure mode of the surrounding shoulders, that the missing shoulder from bearer 22 was also subject to a fatigue failure (figure 9). This meant that six consecutive shoulders, from bearers 20 to 25 inclusive, were probably fractured along the left-hand closure rail prior to the derailment.

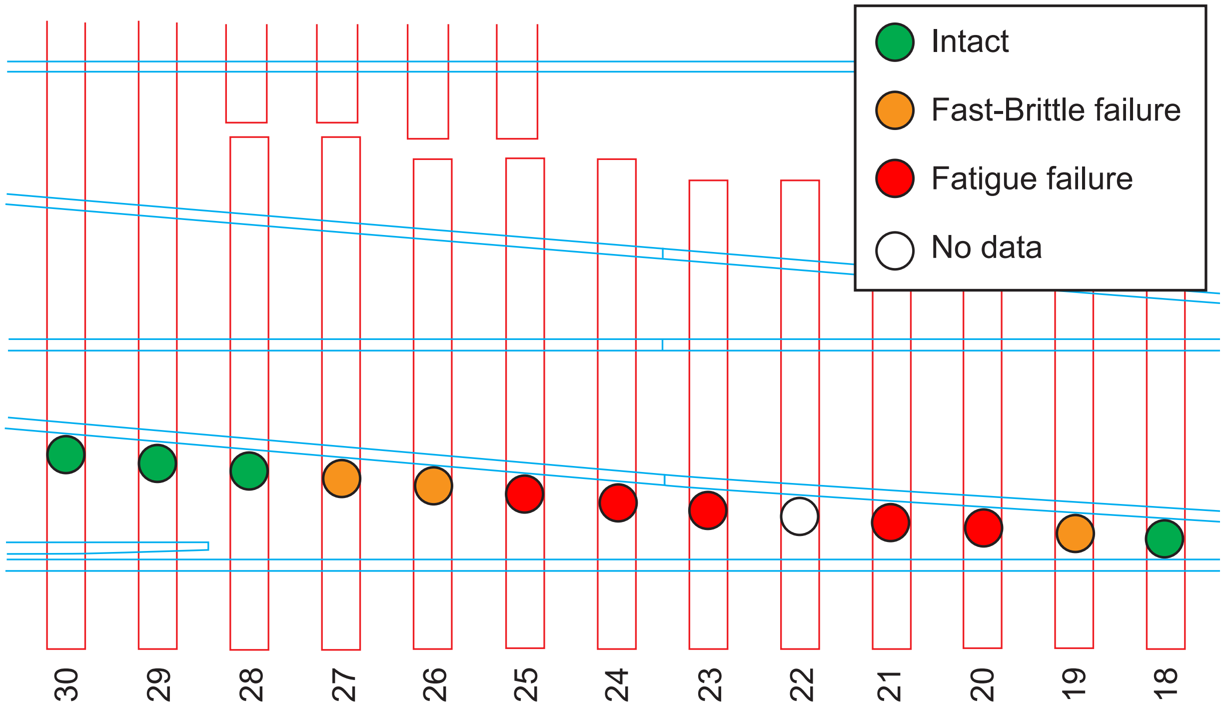

Figure 9: Plan view of the area of derailment, highlighting the shoulders subject to a fatigue (red) or fast-brittle (orange) failure, or were intact (green). The shoulder on bearer 22 (white) could not be positively identified, but probably also failed in fatigue.

Identification of causal factors

44 The derailment occurred due to a combination of the following causal factors:

a. A number of track fastenings had already failed before the locomotive passed over the points. This weakened the track fastening system along the left-hand closure rail (paragraph 46).

b. The lateral forces developed by the locomotive caused additional track fastenings to fail, and this further reduced the capacity of the track fastening system to maintain track gauge (paragraph 78).

Each of these factors is now considered in turn.

Earlier degradation

45 A number of track fastenings had already failed before the locomotive passed over the points. This weakened the track fastening system along the left-hand closure rail.

46 A fatigue failure in metal components occurs when they are subject to a cyclic load that is not sufficient on its own to cause an overload failure, but which can nevertheless initiate microscopic cracks. Over time, and under further cyclic loading, these cracks can grow and propagate through a material, reducing its strength and making it increasingly vulnerable to further crack propagation and overload failure.

47 Metallurgical analysis showed that the shoulders from 450A points that had failed in fatigue had done so prior to the derailment. While this analysis was not able to quantify exactly how long a period these failures had existed for, corrosion on the fracture faces suggested that some had been in a failed condition for at least several months prior to the derailment, while others had failed more recently. The fracturing of these shoulders would have reduced the capacity of the track fastening system to maintain the required track gauge.

48 This causal factor arose due to a combination of the following:

a. The design of the track fastening system made the cast iron shoulder stem more prone to fatigue failure under high lateral forces (paragraph 50).

b. Routine maintenance inspections were not capable of detecting and addressing broken shoulder stems (paragraph 58).

Each of these factors is now considered in turn.

Design of the track fastening system

49 The design of the track fastening system made the cast iron shoulder stem more prone to fatigue failure under high lateral forces.

50 The track fastening system which supports the closure rails was of a modified design, developed by BBRE for RT60 layouts such as Eastleigh (paragraph 35). The system included cast iron shoulders, fixed to the bearer either side of the rail (shown in purple and yellow in figure 10). This design also placed a cast iron wedge under the rail to facilitate its rotation to the required 1 in 20 rail inclination, while keeping the top of the concrete bearer at a consistent level for ease of manufacture.

51 In other parts of the layout, BBRE baseplates[10] were used between the shoulders, instead of the wedge. Some of these baseplates were wide enough to accommodate two rails and so needed to be deeper than a standard baseplate to support the increased load. The wedge on standard bearers needed to be sufficiently thick to maintain the same assembly height as these thickened baseplates to allow a constant construction height (the height from the bottom of the bearer to the top of the rail) to be maintained throughout the layout.

52 It is the need to accommodate these different elements that led BBRE to use an elevated type of shoulder as part of its modified track fastening system. In this design, the base of the rail abuts the insulator (blue in figure 10) on the outer shoulder (purple) at a nominal height of 48 mm above the top of the bearer. In comparison, this height would normally be around 10 mm on most railway sleepers used in the UK. This increase in height resulted in an elevated loading point and a significant increase in the bending forces applied to the shoulder stem under lateral loads.

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[10] Cast iron units attached to sleepers or bearers to support the rail. In the RT60 BBRE layout used at Eastleigh, the baseplates are attached to the cast iron shoulder in the bearer with Pandrol ePlus clips (paragraph 35), and to the rail with further clips inserted into shoulders fabricated into the baseplate.

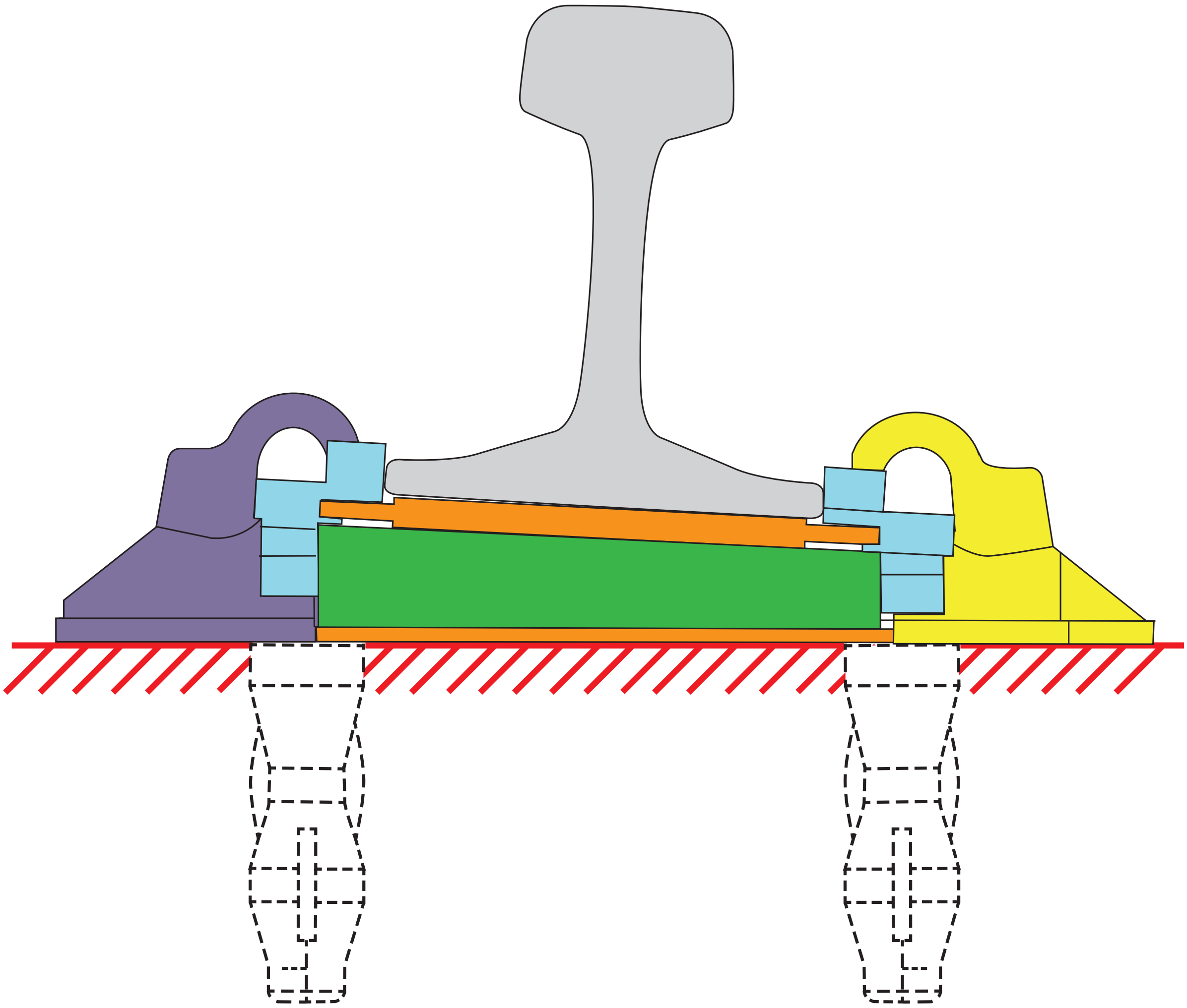

Figure 10: Cross section of a BBRE RT60 layout highlighting the cast iron wedge (green) and elevated shoulder (purple).

53 Before the modified track fastening system could be used, it needed to gain product acceptance from Railtrack. Railtrack's instructions to the manufacturers stated that they needed to comply with two standards that were in draft at the time, with some amendments required for any components to be used on Railtrack's infrastructure. These standards were:

- Draft European standard prEN13481 'Track – general performance requirements for fastening systems'
- Draft European standard prEN13146 'Track – test methods for fastening systems'.

54 Draft European standard prEN13146 required repeated load testing. This included the application of three million loading cycles, at a rate of 4 Hz, varying in load between 5 kilonewtons (510 kg force) and 100 kilonewtons (10.2 tonnes force), which was designed to be '*representative of the displacements caused by traffic on railway track … for assessing the long-term performance of direct fastening systems*'. While the track fastening system used at Eastleigh would have seen a significantly higher number of loading cycles than this test requirement during its operating lifetime, the standard stated that, based on historical data, a three million loading cycle test would be sufficient to detect fatigue failures while remaining practical to undertake.

55 BBRE commissioned testing of the modified track fastening system as required by these standards. The testing results for the system demonstrated that it complied with the requirements of both standards. On this basis, Railtrack's product acceptance procedure considered that the modified track fastening system was suitable for use in service.

56 Although the modified system was tested and found to be compliant with these standards, RAIB considers the increased bending moment caused by the elevated position of the loading point nevertheless made this design of shoulder more prone to fatigue failure under repeated high lateral loads (see paragraph 78) when compared to a standard rail fastening assembly.

Detection of the fault

57 Routine maintenance inspections were not capable of detecting and addressing broken shoulder stems.

58 Metallurgical analysis of the failed shoulder stems (including the three missing immediately prior to the derailment, paragraph 23), showed that at least five, and probably six, of them had failed in fatigue and were broken prior to the derailment (paragraph 48). The analysis was not able to exactly quantify how long a period these failures had existed for, but corrosion on the fracture faces suggested that some had been broken for at least several months.

59 Module 2 of NR/L2/TRK/001 mandates the frequency of visual inspections of the track based on the track category[11] and the seniority of the person undertaking the inspection. These range from frequent, basic visual inspections (BVIs) by patrollers, to less frequent inspections by the SM[T] and/or TME that also include measurements of the track geometry. The standard also provides allowances to permit any missed inspections to be addressed.

60 Network Rail stated that the down slow line, 450A points and the crossover between 450A and 450B points were in track category 2. This meant that the minimum frequency of BVIs was once every 2 weeks, with an inspection by the SM[T] every 13 weeks and by the TME every 2 years. Records provided to RAIB by Network Rail indicate that the inspections required at Eastleigh West Junction were undertaken within these prescribed timescales. This included the period when some shoulder stems were in a failed condition.

61 Despite this, no fault with the fastenings was noted on the relevant site inspection paperwork. This was due to a combination of the following:

a. the failures occurred below the surface of the bearers, so were not visible to staff undertaking visual inspections until the shoulder detached (paragraphs 63 to 65)

b. measurements undertaken as part of inspections had not identified adverse track geometry (paragraphs 66 to 69)

c. despite previous similar failures, Network Rail had not introduced an effective inspection regime which could have detected these failures (paragraphs 70 to 77).

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[11] The track category is a measure of loading on a given section of track, based on a combination of the speed and volume of traffic.

Failure not visible

62 While some failed shoulders were found to be missing from 450A points immediately before the derailment (paragraph 23), metallurgical analysis showed that a larger number had remained in place even after they had failed in fatigue (paragraph 41). This was possibly due to the holding force provided by the ePlus clip (paragraph 35) and the restraint provided by the epoxy grout surrounding the shoulder stem above the fracture. This meant that, in many cases, a shoulder which had a failed stem looked no different to an intact one, when subject to routine visual inspection.

63 While it is possible that there may have been some slight movement in the failed shoulders when they were viewed under a passing train, and that this might have allowed the failure to be detected, there is no requirement under NR/L2/TRK/001 for a visual inspection to observe track under such conditions. Observing slight movement of a failed shoulder would also have necessitated track workers getting very close to a passing train, exposing them to the risk of being struck.

64 For these reasons, RAIB considers that the visual inspections required by NR/L2/TRK/001 during the period in which failed shoulders were present would not have detected this fault.

Track geometry measurements

65 Various measurements of the track are taken and monitored by Network Rail as part of its maintenance regime, which is intended to ensure that the track continues to be safe for the passage of trains. Module 11 of NR/L2/TRK/001 requires lines categorised as track category 2 (paragraph 61) to have their track geometry measured once every 12 weeks. Much of this measurement activity is undertaken by a specialist fleet of track measurement trains, which periodically traverse the main routes. Track measurement trains allow for dynamic measurement of the track geometry, which will show how it performs while a train is passing over it. An increase in track gauge detected by a track measurement train at a location may be an early indication of the failure of the rail fastening system.

66 A track measurement train had passed over the down slow line and the crossover between 450A and 450B points prior to the derailment. However, this track measurement train was not programmed to record the geometry of the crossover which contained the closure rail where the fastenings were later found to have failed. This is because the down fast line was measured separately, and the measurement of the down slow finished at the southern end of platform 2. In these circumstances, module 11 of NR/L2/TRK/001 required measurements to be taken using either hand-propelled track recording devices or manual track gauges. However, because these manual methods do not include the effects of the lateral loads which a track measurement train would exert, they will not, on their own, provide a dynamic measurement of the track gauge.

67 The crossover between 450A and 450B points was being manually measured as part of the SM[T]'s periodic inspection of the points and an inspection of this type, which included 450A points, was undertaken six weeks before the derailment. No faults were noted by the person who undertook this inspection. Although there is evidence that this inspection included the required track geometry checks, module 11 does not require any measurements made to be recorded unless there is cause for concern during the inspection. As no such concerns were raised during the inspection, no track geometry measurements were recorded.

68 Given the number of shoulders that had failed, it is probably the case that the dynamic track gauge over the 450A and 450B points crossover would have been deteriorating before the derailment occurred, and that this would have been detected by the passage of a track measurement train. It is less likely that this deterioration would be measurable during a manual inspection, such as the SM[T] inspection undertaken in the weeks prior to the derailment. Small differences in track geometry between SM[T]'s inspections may also go unnoticed, as track gauge readings are not recorded on the inspection sheet. This means that they are less likely to help maintenance staff to identify progressively deteriorating trends.

Historic failures elsewhere

69 In 2015 and 2016, Network Rail identified failures in the shoulders of track fastenings on BBRE RT60 layouts, across a number of sites. This led to visits being made by specialists from Network Rail's Safety, Technical and Engineering (STE) department (now known as the Technical Authority).

70 In addition to shoulders which had failed in a similar way to that seen in the Eastleigh derailment, STE specialists noted that affected bearers exhibited longitudinal cracks in the concrete between the shoulders. STE's investigation concluded that these cracks had allowed the shoulders to become loose within the concrete, leading to the failures, and that the presence of cracks in bearers would indicate a potential for further failures.

71 In response to these findings, STE published a special inspection notice (SIN), NR/SIN/150, in September 2016. This required track maintenance staff to inspect BBRE RT60 S&C layouts for longitudinally cracked bearers, and if multiple, adjacent cracked bearers were found, to take remedial action. This would consist of ensuring the track gauge was controlled using tie bars, a temporary measure to hold the rails at the correct track gauge, with any further remedial work agreed by the appropriate engineer at route level.

72 No other method of inspection of BBRE RT60 S&C layouts was proposed, as Network Rail believed that the SIN would successfully identify locations where a shoulder failure could occur. In the absence of multiple cracked bearers, there was also no ongoing requirement to continue to check BBRE RT60 S&C layouts for cracking after this initial inspection was completed, although these layouts would be subject to the normal inspection requirements of NR/L2/TRK/001, which remained unchanged.

73 Network Rail has stated that, as well as raising awareness of the failure and requiring a one-off inspection of the S&C involved, the SIN was also intended to identify any affected sites and to gather information about other fastening failures that had not been previously identified.

74 Following the derailment at Eastleigh West Junction, Network Rail's Wessex route, in consultation with RAIB, commissioned the Building Research Establishment (BRE) to undertake an analysis of a sample of ten concrete bearers recovered from the derailment site. Four of these bearers were taken from 450A points (bearers 20 to 23) and the remaining six from 450B points. The aim of this analysis was to determine why the fastenings had failed, and to assess the relative importance of cracking in the concrete bearer, and the integrity of the epoxy grout which holds the shoulders in place.

75 BRE undertook an assessment of the bearers to identify the extent of cracking and other damage. A key finding from this analysis was that the longitudinal cracking exhibited at the surface of the concrete was shallow and likely to be a result of the shrinkage during the drying process and during its operational life. The analysis found that the cracks were unlikely to have had any effect on the security of the fastenings, as the cracks did not propagate through the epoxy grout. While metallurgical analysis showed that some of the shoulders from 450A points had failed in fatigue prior to the derailment (paragraph 48), the BRE report showed that there was no issue with the interfaces between the shoulder stem, the epoxy grout and the concrete which would have contributed to these failures.

76 This shows that the presence of cracking in concrete bearers is not necessarily a precursor to a shoulder failure in a BBRE RT60 S&C layout. It also means that STE's conclusion that the cracking of the bearers was an indicator of potential future failures, which acted as the basis for NR/SIN/150, was not correct.

Lateral forces at 450A points

77 The lateral forces developed by the locomotive caused additional track fastenings to fail, and this further reduced the capacity of the fastening system to maintain track gauge.

78 The class 70 locomotive is one of the heaviest operating on Network Rail infrastructure, and the increased length of a three-axle bogie can lead to it exerting higher curving forces as compared to a two-axle design. The route over 450A and 450B points is regularly used by class 70 and other similar types of locomotive.

79 Lateral track forces generally increase with reducing curve radius. The track through the crossover route of 450A points includes a tight curve of 195 metres radius. This curve, combined with the increased bogie length of a class 70 locomotive, means that the track within the points would be subject to high lateral forces. These forces are normally prevented from moving the rails by track components, including the fastening system.

80 As well as pre-existing fatigue failures of some track shoulder stems, an examination of 450A points following the derailment showed that there had been fast-brittle failures in three of the shoulder stems (paragraph 44). A fast-brittle failure can occur in high strength, low ductility metals such as cast iron. It typically occurs when an item is subjected to a very high load and cracks suddenly and completely.

81 This type of failure suggests that these shoulders were intact prior to the derailment, and their failure was caused by them being overloaded during the passage of the train. These additional failures would have further weakened the track fastening system's restraint of the closure rail, allowing further widening of the gauge and increasing the likelihood of derailment.

82 As discussed in paragraph 47, the presence of high lateral forces in these points was also one of the causes of the earlier fatigue failures seen in the shoulders.

Observations

Eastleigh Maintenance Delivery Unit (MDU)

83 The track maintenance department at Eastleigh MDU was not effectively managing the maintenance of its assets.

84 RAIB investigated a near miss with a track worker, who was based at Eastleigh MDU, at Shawford, in June 2016 (RAIB report 05/2017). The investigation highlighted that a significant number of work orders were not undertaken by their planned date, resulting in a backlog of work. At the time of the incident, the rail testing and lubrication team involved in the incident was the responsibility of the Eastleigh TME. The team was not resilient to any loss of resource or sudden increase in workload, and was reliant on contractors to prevent any further increase in the backlog.

85 Prior to this derailment, Network Rail's Wessex route had identified concerns with the track maintenance department at Eastleigh MDU and was in the process of introducing remedial measures. These included reducing the geographical size and complexity of the Eastleigh TME's area of responsibility, and introducing an additional IME[T] role, with a specialist track maintenance focus, to assist the Eastleigh TME. The Eastleigh TME's responsibility for the Bournemouth and Southampton sections was transferred to other TMEs in the three weeks immediately before the derailment. At the time of the derailment, these changes had not yet resulted in a significant improvement.

86 In response to the derailment, Network Rail's STE department undertook an assurance review into the track maintenance department at Eastleigh MDU. This found evidence that risks were not being effectively controlled and that there was a culture in which the reactive replanning of work had become accepted practice. The review also found that Network Rail's asset management system was not being used correctly.

Preservation of evidence

87 Potential evidence from bearers that were part of 450A points was lost.

88 Before the removal of the damaged 450A points, RAIB required Network Rail to preserve six bearers for further analysis. However, during the reinstatement works undertaken by Network Rail, two of these bearers were lost, and subsequent searches could not locate them. The remaining four bearers were recovered successfully. It cannot be known what evidential value the two lost bearers may have had, but they had the potential to inform RAIB's and Network Rail's investigations into the derailment.

89 Regulation 8 of The Railways (Accident Investigation and Reporting) Regulations 2005 requires railway industry bodies, such as Network Rail, to preserve evidence when directed to do so by RAIB. Network Rail has been unable to explain why it did not preserve this evidence as it was directed to do on this occasion.

Summary of conclusions

Immediate cause

90 The track was unable to maintain the correct gauge as the train passed over 450A points (paragraph 39).

Causal factors

91 The causal factors were:

a. A number of track fastenings had already failed before the locomotive passed over the points. This weakened the track fastening system along the left-hand closure rail (paragraph 46). This causal factor arose due to a combination of the following:

   i. the design of the track fastening system made the cast iron shoulder stem more prone to fatigue failure under high lateral forces (paragraph 50, no recommendation)

   ii. routine maintenance inspections were not capable of detecting and addressing broken shoulder stems (paragraph 58, **Recommendations 1 and 2**, and **Learning point 1**).

b. The lateral forces developed by the locomotive caused additional track fastenings to fail, and this further reduced the capacity of the fastening system to maintain track gauge (paragraph 78, no recommendation).

Observations

92 Although not linked to the accident on 28 January 2020, RAIB observes that:

a. The track maintenance department at Eastleigh MDU was not effectively managing the maintenance of its assets (paragraph 84, no recommendation).

b. Potential evidence from bearers that were part of 450A points was lost (paragraph 88, **Learning point 2**).

Previous RAIB recommendations relevant to this investigation

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

Derailment at Windsor and Eton Riverside station, 11 October 2009

94 RAIB investigated a derailment of a charter train at Windsor and Eton Riverside station, Berkshire (RAIB report 11/2010). As the train approached the buffer stops, the rails spread underneath it, allowing the leading wheelset of the leading coach to derail. The investigation found that the poor condition of some of the sleepers allowed the rails to move apart. This fault had been identified four years prior to the derailment, but a discrepancy in the recording of the fault meant that it was not adequately monitored.

95 RAIB also found that the dynamic track gauge at the location was not being recorded, as a track measurement train was not monitoring this section of track. Network Rail had no other systematic method of assessing the change in track gauge under dynamic conditions.

96 Following the accident, RAIB made the following recommendation:

> *Recommendation 2*
>
> *Network Rail should develop a proposal for the periodic measurement of dynamic gauge at potentially vulnerable locations not covered by a track recording vehicle, and implement the identified measures, as appropriate.*

97 On 17 October 2013, the Office of Rail and Road (ORR) reported to RAIB that this recommendation had been implemented by alternative means by Network Rail, with the following comment:

> *'ORR has concluded that Network Rail has considered how potentially vulnerable parts of the network that are not covered by track recording vehicles can be subject to dynamic gauge measurement.*
>
> *Network Rail concluded that: …the underlying issue was non-compliance with company standards and that if action had been taken in accordance with specified minimum actions derailment risk would have been mitigated… and that …the consequential risk posed at these locations is not considered significant as a consequence of their track category assessment.*
>
> *However, Network Rail has introduced a new Track Geometry Measurement system (TrueTrak) which has been successfully installed on two Track Recording Vehicles, with a lower cut–off speed of 7 mph. These vehicles have just entered into production service and have not yet operated for a sufficient amount of time to demonstrate the delivery of additional gauge data.'*

Derailment at Liverpool Street station, London, 23 January 2013

98 The investigation into a derailment of a passenger train at Liverpool Street station, London (RAIB report 27/2014), found that the train derailed on a tight curve with non-standard trackwork. Mitigation measures to manage the enhanced derailment risk at this location were not in place because local maintenance management staff did not have the necessary knowledge to understand these risks or to implement appropriate controls. The investigation found that there were particular issues with maintaining the gauge of the track, due to a degradation in the strength of the rail fastenings. RAIB also found that the manual track measurement methods in use at the location did not report, and possibly did not identify, wider than normal static track gauge or indications of a loss of strength in the fixing between the rail and sleepers.

99 Following the accident, RAIB made the following recommendation:

Recommendation 1

Network Rail should improve its management systems so that both the identification of all non-standard track assets, and the associated inspection regimes intended to manage any enhanced risk of derailment, are recorded and independently checked. The scope of these inspection regimes should include mechanisms for identifying indications of possible gauge widening and, where necessary, assessing dynamic track gauge.

100 On 12 June 2020, ORR reported to RAIB that this recommendation had been implemented by Network Rail, with the following comment:

> *'Network Rail reviewed its track management system and found it be sufficiently robust. However, shortcomings were identified with different interpretations of standards, so a Track Work Information sheet (TWI) has been produced aimed at standardising the approach to identifying higher or unusual risk assets and suggesting possible suitable mitigations. Network Rail have now confirmed that the TWI has been briefed to TME and RAM (track) in each route.'*

101 RAIB also included six learning points. One was particularly relevant to the derailment at Eastleigh as it noted the need for effective management of track gauge, including in areas of intensive train services, where this is not monitored by track recording trains.

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

102 Following the derailment, Network Rail's Wessex route issued a local instruction to manage the immediate risk on other BBRE RT60 layouts on its route. Subsequently, Network Rail STE issued a new special inspection notice, NR/SIN/191. As with the earlier NR/SIN/150, this notice asked MDUs on each route to check for the presence of, and to inspect, BBRE RT60 S&C layouts. This notice also included a tactile inspection of the shoulders within the layout to check for any movement.

103 Network Rail identified 499 BBRE RT60 S&C layouts that required inspection. NR/SIN/191 prioritised inspections based on the perceived risk of failure. This meant that layouts on main lines with a high volume of traffic and on tight curves were to be inspected before other layouts.

104 Network Rail, led by Wessex route, is undertaking further testing and research to try and develop a better understanding of this particular failure mechanism and establish ways of monitoring such S&C in the future.

105 The measures that were being implemented within the track maintenance department at Eastleigh MDU (paragraph 84) have continued. Wessex route has reported that the backlog of work has been cleared and that it has now addressed the findings of the Network Rail STE assurance review (paragraph 85).

106 Network Rail has reported that the design of cast iron shoulder used on the layouts at Eastleigh West Junction is no longer in production, other than as spare components for existing layouts. Newer NR60 S&C units now use a raised, inclined rail seat that eliminates the need for an elevated shoulder. In addition, all bearers now have the shoulders cast into the bearer at manufacture, rather than installed by the drill and grout method (paragraph 36b).

107 On 5 December 2020, Network Rail updated standard NR/L2/TRK/001 module 5, 'Switches and Crossings', to include a specific section on the inspection of BBRE RT60 concrete bearer S&C layouts. This updated module has a compliance date of 6 March 2021. The updated module requires a specific yearly inspection of BBRE RT60 layouts with a switch radius of less than 250 metres or at sites of previous failures, or every two years on other BBRE RT60 layouts. It also includes guidance on tell-tale signs of failure, and states that '*cracks in the concrete bearer emanating from the housing are a common feature in BBRE RT60 layouts and should not exclusively be used as a tell-tale sign*'.

Recommendations and learning points

Recommendations

108 The following recommendations are made:[12]

1 *The intent of this recommendation is to reduce the risk of failure of elevated cast iron shoulders, such as those on RT60 S&C layouts.*

Network Rail should develop a strategy to assess and control the risk of failure of track fastening systems incorporating elevated shoulders in RT60 switch and crossing layouts. It should also confirm that the failure mode identified in these shoulders does not apply to other elevated designs of track fastening system (paragraph 92a.ii).

2 *The intent of this recommendation is that Network Rail considers how dynamic track gauge measurement is undertaken in the areas of its network that are not traversed by its track measurement trains.*

Network Rail should review its arrangements for the dynamic measurement of track geometry on the parts of its infrastructure not covered by its track measurement trains. The review should include the identification of high risk locations where additional safeguards are required (such as those subject to high lateral forces, or where there is an increased risk of track geometry faults). Consideration should be given to the number and routing of track measurement trains and alternative ways of measuring track geometry under dynamic conditions. Any additional safeguards identified by this review should be implemented by means of a risk-based programme (paragraph 92a.ii).

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[12] 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

109 The RAIB has identified the following learning points:[13]

1 It is important that the possible causes of faults and failures are correctly identified and that any subsequent actions, such as the issuing of inspection notices or changes in maintenance and inspection routines, are effective at controlling the ongoing risks (paragraph 92a.ii).

2 Railway industry bodies are reminded of the importance of preserving evidence required for a safety investigation, and of their duties to do so under The Railways (Accident Investigation and Reporting) Regulations 2005 (paragraph 93b).

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[13] '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

BBRE	Balfour Beatty Railway Engineering
BRE	Building Research Establishment
BVI	Basic visual inspection
CCTV	Closed-circuit television
IME	Infrastructure maintenance engineer
IME[T]	Infrastructure maintenance engineer [track]
MDU	Maintenance delivery unit
ORR	Office of Rail and Road
OTDR	On-train data recorder
RAIB	Rail Accident Investigation Branch
RAM (track)	Route asset manager responsible for track assets
S&C	Switches and crossings
SIN	Special inspection notice
SM[T]	Section manager [track]
STE	Network Rail Safety, Technical and Engineering
TME	Track maintenance engineer
TWI	Track work instruction

Appendix B - Investigation details

RAIB used the following sources of evidence in this investigation:

- information provided by witnesses
- information taken from the train’s on-train data recorder (OTDR)
- forward facing CCTV recordings
- site photographs and measurements
- weather reports and observations at the site
- maintenance records relating to the locomotive and the infrastructure
- reports from special contractors that were commissioned by Network Rail
- review of relevant industry standards and procedures
- a review of previous RAIB investigations that had relevance to this accident.

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Any enquiries about this publication should be sent to:

RAIB
The Wharf
Stores Road
Derby UK
DE21 4BA

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