Rail Accident Investigation Branch

Rail Accident Report

Derailment of a freight train near Wanstead Park, London
23 January 2020

Report 12/2020
November 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.

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

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

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.

This page is intentionally left blank

Derailment of a freight train near Wanstead Park, London, 23 January 2020

Contents

This page is intentionally left blank

Summary

Shortly before 06:00 hrs on Thursday 23 January 2020, a wagon in the rear half of a heavily loaded freight train derailed on a small radius curve as it crossed a bridge in east London. The forces from the train caused the rails on the bridge, which were attached to large longitudinal timbers, to spread apart. Two adjacent wheelsets from different wagons derailed, but one wheelset re-railed itself after travelling a short distance. The other wheelset remained derailed as the train continued for 2.5 miles (4.1 km) before stopping, and this caused significant track damage. Wagons positioned behind the derailed wagons remained on the track.

Track where the rails are supported on longitudinal timbers is subject to special inspections by staff who have received additional training to undertake this role. RAIB found that the condition of the timbers at the point of derailment had severely deteriorated because of rot, but this was concealed by their superficially good exterior condition. The inspection method and tools used by Network Rail staff were not sufficient to detect the poor internal condition of the timber.

The widening of the track gauge was identified, by track recording vehicles operated by Network Rail, six times between March 2019 and January 2020. On three occasions, the track maintenance gangs responded but undertook work in a nearby location due to erroneous GPS data. On three other occasions, the track recording vehicles' software did not report the location of the fault so maintenance staff remained unaware of it.

One wagon in the train exerted sufficient force on the weakened track support to force the rails apart and cause the wagon to derail. Examination of the first wagon to derail and its maintenance records indicated that it had experienced unusually rapid wheel wear over several years. It is possible that this meant it was imposing higher than normal lateral forces on the track and that this is related to a defect which affected the way the bogie was able to rotate.

Following the failure of a longitudinal timber on a bridge in the same area in August 2017, Network Rail launched a review resulting in an updated standard for the detailed inspection and management of longitudinal timbers. The updated standard was under development at the time of the accident, and was published in March 2020.

RAIB has made one recommendation to Network Rail regarding improvements in the provision of track recording vehicle data to track maintenance staff, and one recommendation to the wagon owner concerning the monitoring of maintenance activities to reduce the risk of defective rail vehicles entering service. It has identified three learning points covering the management of longitudinal timber systems and loading activities in freight loading terminals.

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 References to left and right refer to the train's direction of travel when the accident occurred.

3 Appendices at the rear of this report contain the following glossaries:

- acronyms and abbreviations are explained in Appendix A
- sources of evidence used in the investigation are listed in Appendix B.

The accident

Summary of the accident

4 At about 05:54 hrs on Thursday 23 January 2020, two adjacent wagons, positioned towards the rear of a 22-wagon freight train, became derailed between Woodgrange Park and Wanstead Park in north-east London. The rear wheelset of the leading of these wagons derailed with its right-hand wheel dropping to run inside the right-hand rail. The derailment occurred on a curve when rail movement resulted in an increase in the distance between the rails, known as gauge widening or a wide gauge fault. This occurred on a bridge on which the rails were supported on longitudinal timbers running continuously beneath each rail.

5 About seven metres beyond the initial point of derailment (POD), and at the end of the bridge, the leading left-hand wheel of the following wagon derailed with its left-hand wheel running inside the left-hand rail. The five following wagons continued without derailing after the rails were able to move back and the gauge reduced.

6 The derailed train continued for 4.1 km (2.5 miles), travelling at up to 35 mph (56 km/h) and causing extensive damage to the track. The driver was unaware of the derailment until the brake pipe between the two affected wagons separated causing the train brakes to apply automatically. The train came to a stand between Leyton Midland Road and Walthamstow Queens Road stations (figure 1).

7 The railway between Woodgrange Park Junction and South Tottenham East Junction was closed for repair for 27 days, reopening on 19 February 2020.

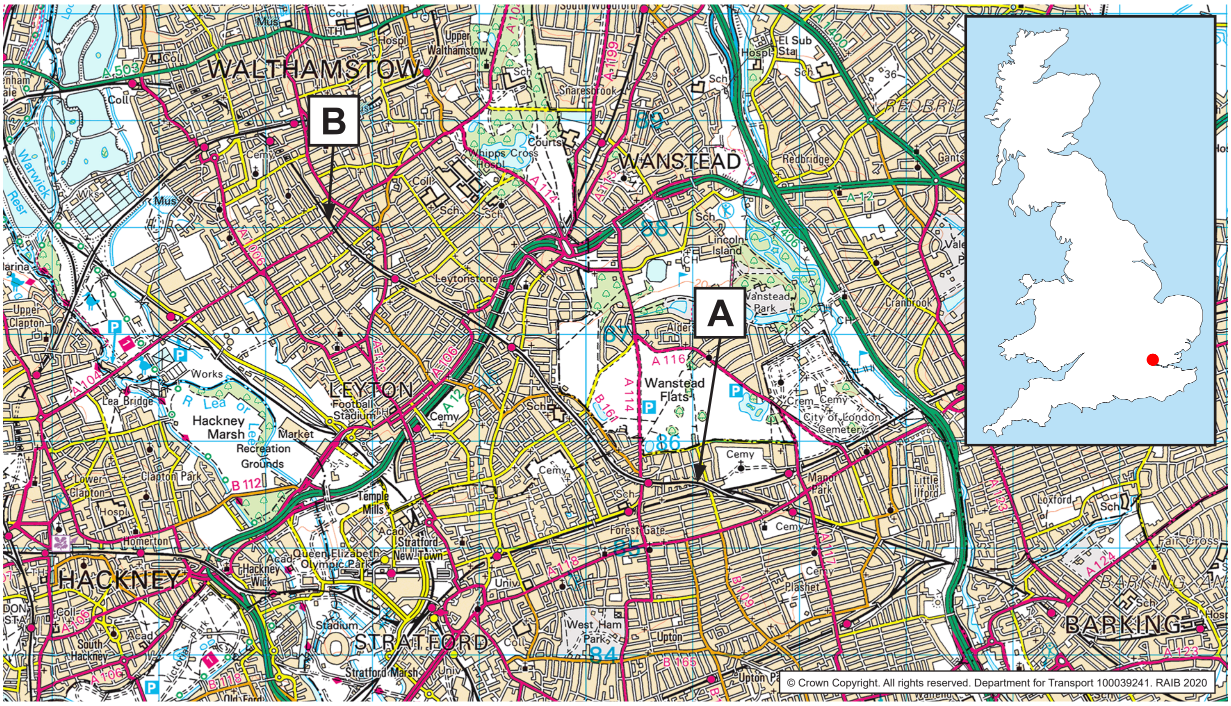


Figure 1: Extract from Ordnance Survey map showing location of accident. Wagon number 3415 derailed at 'A'. The train came to a stand at 'B'

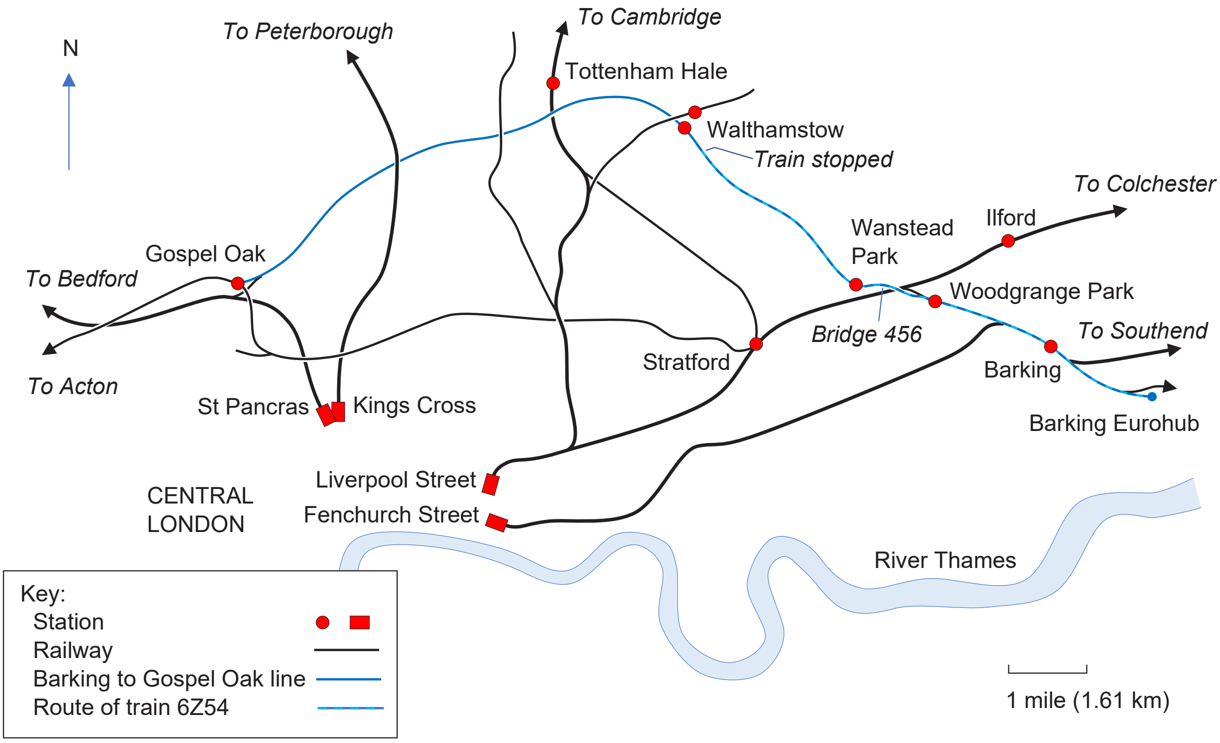


Figure 2: Main railway lines in north-east London

8 There were no injuries. Part of the brake system on wagon number 3415 became detached because of vibration caused by the derailment. There was some consequential damage to the underside of the wagon's body and wheels.

9 Infrastructure repair work included replacing 39 pieces of rail, 5,300 concrete sleepers, 900 wooden sleepers, removing and replacing 10,000 tonnes of ballast and replacing timbers supporting the track at 10 bridges. Lineside cables and signalling equipment were also repaired.

Context

Location

10 The Barking to Gospel Oak (Hampstead) line runs in an arc across north-east London, passing through Walthamstow and Tottenham (figure 2). Electrification of the line was completed in 2018. The route now carries a local passenger service every 15 minutes in each direction, and longer-distance freight trains. In the 12 years prior to the derailment, the route saw a 500% increase in the amount of traffic, due to increased passenger services and the opening of new freight and port facilities in east London and Essex (paragraph 55).

11 The train involved in the accident (train reporting number 6Z54) was travelling west on the up Tottenham & Hampstead line. The derailment occurred as the train crossed bridge TAH2/456 spanning Lorne Road, a residential road in Forest Gate. The bridge is located at 11 miles 825 yards.[1] It forms part of a 4.9 km long section of elevated railway with numerous metal bridges spanning roads, interspersed with masonry arched viaducts and some short sections of embankment.

[1] Measured from London St Pancras.

12 Bridge 456 is located at the top of a steep gradient ascended by trains travelling west from Barking. The 1 in 65 (1.53%) gradient extends for 0.7 km from Woodgrange Park Junction, reducing to 1 in 190 (0.52%) at bridge 456. This gradient continues for 0.1 km beyond bridge 456, and the track is then level for 0.4 km to Wanstead Park station. Bridge 456 is located near the mid-point of a 0.2 km long, 400 metre radius left-hand curve (figure 3).

Figure 3: Aerial view of bridge 456 and bridge 448 looking north-west (courtesy of Network Rail)

Organisations involved

13 Network Rail owns and maintains the infrastructure. It was the employer of staff involved in the inspection and monitoring of the track across bridge 456.

14 DB Cargo was the operator of the train and employer of the train driver. It was also responsible for the loading of the wagons at Barking.

15 VTG Rail UK Ltd was the owner of the wagons involved, and responsible for their maintenance as the Entity in Charge of Maintenance.

16 The above freely co-operated with the investigation.

Train and wagons involved

17 Train 6Z54 formed the 05:31 hrs service from Barking Eurohub to Calvert, near Aylesbury, via Acton yard. It consisted of 22 loaded JNA, KEA and JXA open bogie box wagons hauled by a Class 66 diesel locomotive (number 66154). Although all three types of wagon had the same capacity, JXA wagons are larger and heavier than the other two types.

18 Wagon 3415, the first wagon to derail, was a JNA bogie box wagon, weighing 27.4 tonnes tare. Its load carrying capacity was limited to 74.2 tonnes so that its gross loaded weight did not exceed 101.6 tonnes, the maximum permitted on Network Rail infrastructure. The wagon was fitted with Davis & Lloyd - ESC1 3-piece bogies, and wheels with a P6 wheel profile (figure 4).

Figure 4: Wagon number 3415 with its rear wheelset derailed to the left. Part of wagon number 3114 is also visible

19 On departure from Barking on 23 January 2020, the train weighed 2170 tonnes, excluding the locomotive, and was carrying 1435 tonnes of clay spoil. It comprised a rake of wagons being used on a daily round trip from Barking to Calvert, returning empty to Barking to be reloaded overnight. Wagon 3415 had travelled loaded as part of the same train on the same route on nine previous occasions during 2020, including on the two previous days.

20 At the time of derailment, the train was running at 22 mph (35 km/h) on a section of line where the maximum permitted speed was 40 mph (64 km/h) and with the locomotive under power as the rear part of the train was still ascending the gradient. There is no indication that the handling of the train had any influence on the cause of the derailment.

21 The second wagon to derail was wagon number 3114. This was a type JXA bogie box wagon, and was positioned immediately behind wagon 3415.

Rail infrastructure and systems involved

22 The railway is double track, and is electrified with 25 kV AC overhead line. It has a maximum permitted speed of 45 mph (72 km/h) in both directions, although this is reduced to 40 mph (64 km/h) in the vicinity of bridge 456 due to the curvature of the line. The track circuit block signalling is operated by a signaller located at South Tottenham Station Junction signal box.

23 The track is formed of continuously welded CEN-60 flat-bottomed rails. Most of the track is ballasted with rails secured to EG47 sleepers by Pandrol FastClips. On bridges fitted with longitudinal timbers, rails are secured by NRS2 baseplates which are attached to the timbers using angled baseplate screws (figure 5 and figure 6).

Figure 5: Bridge 456 following the accident but before removal of the deck walkway

24 On bridge 456, the timbers are held at the correct distance apart by tubular steel transoms which enclose steel tie rods (figure 6). The timbers rest directly on the metal bridge deck and are held in position by metal brackets known as cleats.

25 Supporting running rails on longitudinal timbers, rather than using conventional sleepers and ballast, imposes less weight on the bridge and thereby permits a lighter and shallower bridge structure. This increases the clearance for high vehicles using the roads below. Although less expensive to construct, bridges with longitudinal timber systems (also known as waybeams, longitudinal wheel timbers, or longitudinal bearers) are vulnerable to developing track geometry faults and so have increased inspection and maintenance requirements.

Figure 6: Bridge 456 up deck after removal of the deck walkway

26 Network Rail owns over 2,500 spans where the track is supported on longitudinal timbers, and has a long-term policy for replacing them with ballasted track where possible. This normally requires the complete reconstruction of a bridge to take heavier ballasted track. On Anglia route, there are still about 200 track spans fitted with longitudinal timbers of which about 30% are softwood and the remainder hardwood. A single span bridge carrying two tracks is counted as two track spans in this data, and some larger structures carry one or more tracks over several successive track spans. The 200 track spans represent about 4% of Anglia route's total number of underbridge spans where roads, watercourses or other features pass under the railway.

27 Bridge 456 was constructed in 1893 using fabricated steel girders and a metal deck and the line opened in the following year. The bridge has a single span of 20.5 metres between abutments, which are skewed at 25° to cater for the relative alignments of the railway and Lorne Road. The bridge carries two tracks on separate, parallel decks with two outer main girders, and a central main girder positioned between the tracks.

28 The longitudinal timbers vary in depth between 275 mm on the left-hand (cess) and 350 mm on the right-hand (six-foot) rail. The difference in depth is required to achieve a designed track cross-level (cant) of 75 mm. The longitudinal timbers were last renewed in 2008.

29 Network Rail monitors its track using a fleet of track recording vehicles. These vehicles are formed into trains and cover the national network to a pre-determined schedule. They provide data and information to assist track maintenance staff to locate track faults.

Staff involved

30 A team leader [longitudinal timbers] from Network Rail's Barking depot undertook an annual detailed inspection of the longitudinal timbers at bridge 456 in June 2018. He moved to another role in March 2019.

31 An acting team leader [longitudinal timbers] from Network Rail's Barking depot was appointed in March 2019 following training and a period of mentoring. He undertook an annual detailed inspection of the longitudinal timbers at bridge 456 in June 2019. He was appointed as team leader [longitudinal timbers] in November 2019.

32 An assistant track manager undertook planned supervisor's visual inspections of the longitudinal timbers at bridge 456 on four occasions during 2019.

33 A team leader [track maintenance] from Barking depot led a group of track maintenance staff who attended site in May and June 2019 in response to a wide gauge fault, recorded in the vicinity of bridge 456 by track recording vehicles.

34 The track maintenance engineer (TME) for Barking depot was responsible for reviewing track geometry data recorded by Network Rail's track recording vehicles. He was also the manager of the assistant track manager, team leaders and acting team leader, and responsible for reviewing and signing-off their inspection and maintenance reports.

External circumstances

35 The accident occurred in darkness, about two hours before sunrise. The weather was dry and cloudy with an air temperature of 8°C. This is unlikely to have had any bearing on the accident.

The sequence of events

Events preceding the accident

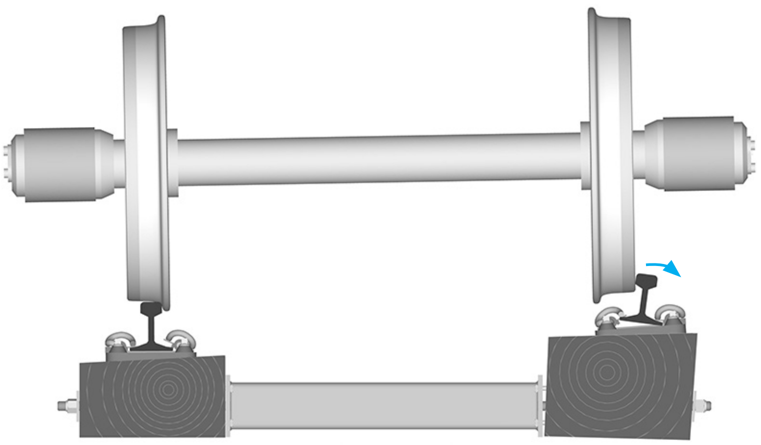
36 Train 6Z54 completed loading at 03:45 hrs on 23 January 2020 and departed from Barking Eurohub at 05:33 hrs. The train proceeded via Barking station and crossed Barking flyover. It passed Woodgrange Park Junction where it joined the up Tottenham & Hampstead line at about 05:49 hrs.

37 The on-train monitoring recorder (OTMR) data from the locomotive indicates that the driver applied full power to climb the 1 in 65 gradient south of Woodgrange Park Junction onto the elevated section of line. The train's speed had reduced from 29 mph (47 km/h) at the junction to approximately 22 mph (35 km/h) when wagon 3415 reached bridge 456.

Events during the accident

38 The right-hand wheel of the rearmost wheelset on wagon 3415 derailed as it passed over bridge 456 (figure 7). Less than a second later, the left-hand wheel on the leading wheelset of following wagon 3114 also derailed causing both rails to rotate outwards (figure 8). The driver was unaware of these events and maintained full power. The train gradually accelerated to 35 mph (56 km/h).

39 Wagon 3114, the second derailed wagon, re-railed itself after travelling approximately 230 metres and crossing two other longitudinal timber bridges. Rerailing occurred before Wanstead Park station, as the left-hand curve started to transition into a right-hand curve.



Gauge widening occurred due a combination of the rotation and compression of the right-hand timbers, baseplate movement (shuffle) and rail rotation

Figure 7: Arrangement of wagon 3415's derailed wheelset immediately after initial point of derailment

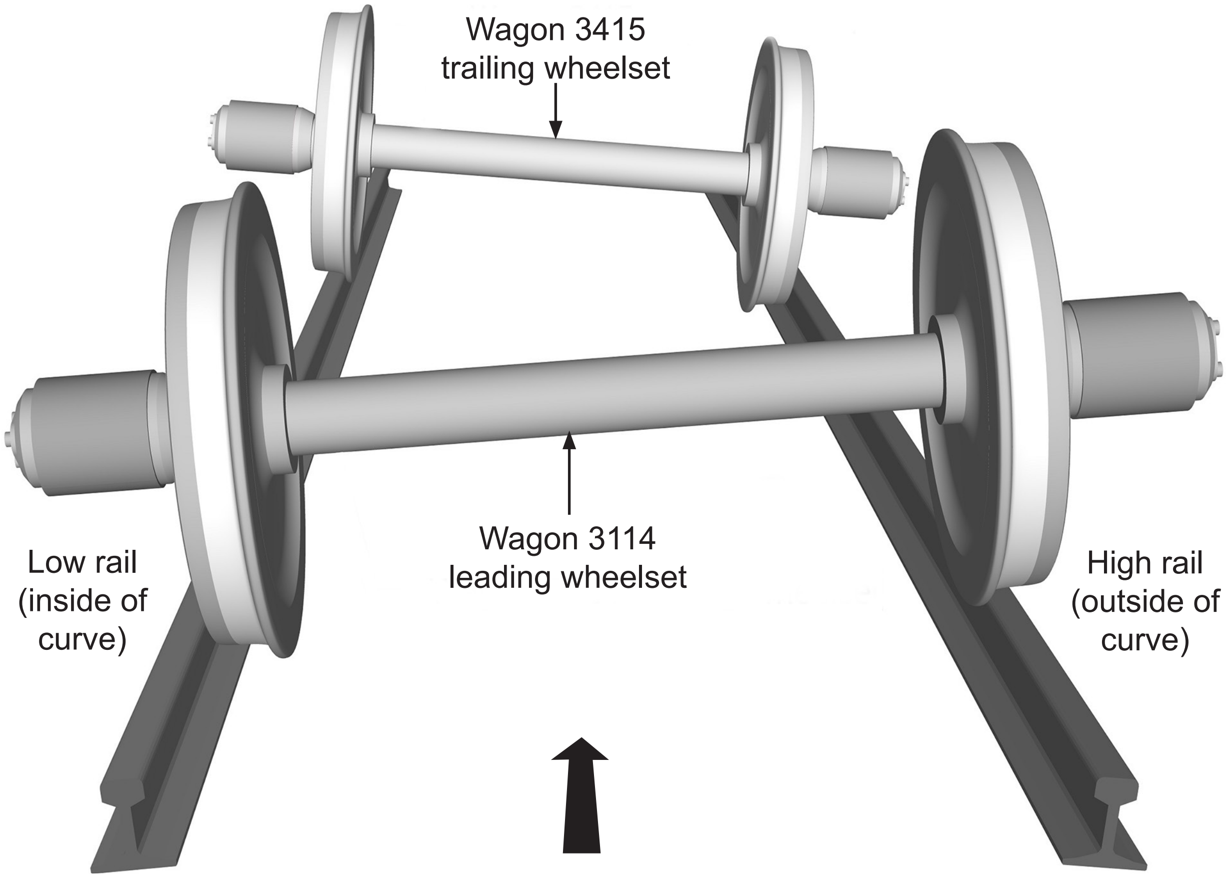


Figure 8: Arrangement of two derailed wheelsets after second derailment with both rails rotated outwards

40 Wagon 3415 continued with its rear right-hand wheel derailed and running inside the right-hand rail for approximately 450 metres. As the train traversed a right-hand curve through Wanstead Park station, marks on the railhead indicate that the associated left-hand wheel climbed over the railhead and derailed to the left. The wagon then continued with both wheels of the rear wheelset of the trailing bogie derailed to the left. In this condition it crossed a further seven longitudinal timber bridges and damaged the track (figures 9, 10 and 11).

Figures 9, 10 and 11: Examples of track damage between point of derailment and location where train stopped

41 The derailed train travelled through Wanstead Park, Leytonstone High Road and Leyton Midland Road stations before the brake pipe separated causing the train brakes to automatically apply. This occurred about six minutes after the derailment, with the train stopping at 8 miles 1300 yards, around 2.5 miles (4.1 km) after derailing.

Events following the accident

42 At 06:05 hrs, the driver informed the signaller of a problem with the train. The driver inspected the train and advised the signaller that one wheel was derailed on a wagon. A Network Rail Mobile Operations Manager attended site and, at 06:53 hrs, advised that there was considerable damage to rails, sleepers and cabling.

Analysis

Identification of the immediate cause

43 The track was unable to maintain the correct gauge as train 6Z54 passed over it.

44 A derailment mark on the inside face of the right-hand rail on bridge 456 showed that a wheel had dropped into the four-foot (the area between the rails) at this location. Another derailment mark was identified on the inside face of the left-hand rail about seven metres beyond the first mark, showing that a second wheel dropped into the four-foot. Post-accident examination of the two wagons involved showed that the wheels on the derailed wheelsets were at the correct spacing. There was no evidence that they had moved inwards, along the axle, at any time. This demonstrates that derailment was a consequence of rail movement causing the track gauge (the horizontal distance between the rails) to increase by at least 85 mm, sufficient to allow the right-hand wheel of a wagon to drop inside the right-hand rail (figure 7). The locations of the derailed wheelsets (trailing on one bogie and then leading on a following bogie) and the wheels (right then left) are consistent with classic curving behaviour of a conventional bogie vehicle on small radius curves, and explain the order that the wheels dropped into the four-foot.

45 The absence of derailment marks on the right-hand wheel of wagon 3114 shows that wagon 3415 derailed at the first (right-hand rail) derailment mark and wagon 3114 at the second (left-hand rail). It is likely that spreading of the rails by the derailed wheelset of wagon 3415 provided room for the leading wheelset of the following wagon 3114 to derail. The absence of significant damage to the left-hand rail at the location where wagon 3415 derailed indicates that the accident was initially caused by the right-hand rail rotating or moving outwards.

46 The relatively low speed of the train meant that the cross-level or cant at this location was greater than required, a condition known as cant excess. When cant excess is present on a small radius curve, the leading outer wheelset on a bogie would be expected to be displaced to the outside of the curve (right wheel) and the trailing wheelset displaced toward the inside (left wheel), and this is the likely reason why it was the right wheel on the trailing wheelset of the trailing bogie of wagon 3415 that dropped into the four-foot.

47 A defect pushing the leading wheelset of the trailing bogie further towards the right-hand rail (paragraph 113) is likely to have increased outward lateral forces on the right-hand rail.

Identification of causal factors

48 The accident occurred due to a combination of the following causal factors:

a. the rail restraint was inadequate leading to a persistent problem with wide gauge (paragraph 49)

b. track recording vehicles identified a wide gauge fault but output derived from this data did not result in track maintenance staff repairing faults at the correct location (paragraph 74)

c. Network Rail was not aware of the severity of the longitudinal timber degradation and so took no action to deal with this (paragraph 95)
d. the condition of the trailing bogie on wagon 3415 imposed unusually high lateral forces on the track (paragraph 111).

Each of these factors is now considered in turn.

49 The rail restraint was inadequate leading to a persistent problem with wide gauge.

50 The up line across bridge 456 was supported by four longitudinal timbers under each rail, each about 6 metres long and laid end to end. The combined length of just over 24 metres was sufficient to cross the bridge and extend a few metres onto the embankment at each end, a feature known as a flying end. This was to provide a transition between the relatively stiff bridge deck and the more flexible ballasted embankment. In the direction of travel, the timbers were numbered R4 to R1 supporting the left-hand rail (cess rail) and 4L to 1L supporting the right-hand rail (six-foot rail). The initial derailment occurred close to the joint between timbers 2L and 1L at the location marked POD 1 on figure 12.

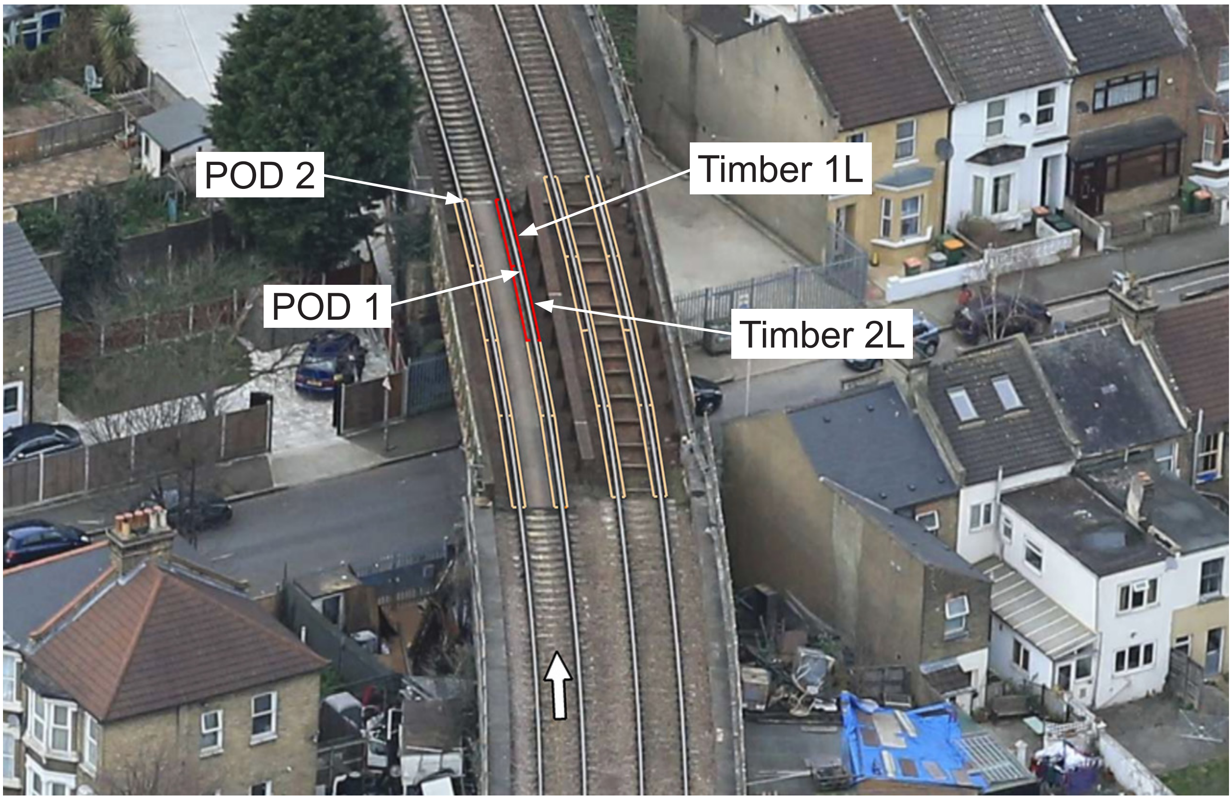


Figure 12: Bridge 456 showing the eight longitudinal timbers on each deck. The timbers associated with the derailment are numbered 2L and 1L.

51 The standard gauge (distance between the vertical faces of two rails on the same track) on Network Rail infrastructure is 1435 mm. Gauge is either measured statically, for instance using a hand-held track gauge, or dynamically when additional deflection due to the forces from passing trains is taken into account. Dynamic measurements can be recorded either by equipment fitted to the track or to a train. The response by maintenance staff to wide gauge faults is specified by Network Rail standard NR/L2/TRK/001 mod11 (issue 8), published September 2015.

52 The standard indicates that for a line on which the maximum permissible speed for trains is between 26 mph and 50 mph (42 km/h and 80 km/h), the following limits apply. If either static or dynamic gauge reaches 1450 mm, the alert limit is exceeded and track maintenance staff are required to plan remedial action. If the static plus dynamic movement reaches 1460 mm, the intervention limit is exceeded and remedial action is required within 14 days, or 36 hours if gauge reaches 1470 mm. If the static gauge plus the additional deflection from passing trains is 1478 mm or greater, the immediate action limit is reached and the line must be immediately blocked to all traffic. These limits are equivalent to wide gauge of 15 mm (alert limit), 25 mm and 35 mm (intervention limits) and 43 mm (immediate action limit).

53 Bridge 456's longitudinal timbers were last renewed in 2008 using Douglas Fir (softwood). Network Rail standard NR/L2/TRK/3038 (issue 4), which was current in 2008, stated:

> *'For complete replacement of Longitudinal Timbers on lines with track categories 1A, 1 and 2 only hardwood shall be used. Hardwood timber shall be used for other lines unless the written approval is obtained from the Railtrack Director's Nominee for the use of softwood.'*

54 The track category is derived from the speed of traffic and equivalent tonnage using the line, and ranges from 6 (low speed and low use) to 1A, the highest. It is used to determine inspection frequencies and renewals specifications. In 2008, this section of line carried 2.9 equivalent million gross tonnes per annum[2] (EMGTPA) and was rated track category 4.

55 Between 2008 and 2018, there was a significant increase in rail traffic using the Barking to Gospel Oak route. During this period the annual tonnage carried increased fivefold from 2.9 EMGTPA to 15.5 EMGTPA. This was due to both the doubling of the frequency of passenger services operated by London Overground, and increased freight traffic associated with Barking Eurohub and the London Gateway container port near Stanford-le-Hope, Essex, which opened in 2013. As traffic increased, the track category changed in steps from 4 to 2. It subsequently dropped back to category 3 in the immediate vicinity of bridge 456 due to the 40 mph (64 km/h) permanent speed restriction at that location. Most of the route remained within track category 2 (paragraph 22).

56 The maximum weight of vehicles permitted over bridge 456 was managed through Network Rail's Route Availability (RA) process. The highest routine category is RA8 which permits rail vehicles with a maximum gross laden weight of 91.4 tonnes, but heavier freight wagons are permitted on some lines by a dispensation issued using Network Rail's RT3973 Heavy Axle Weight process after an assessment by the route's structures and track engineers. Over 25% of loaded freight trains operate under a dispensation. The Barking to Gospel Oak route had a dispensation allowing its use by wagons of the types in train 6Z54 loaded to RA10, a category permitting a maximum gross laden weight of 101.6 tonnes and a maximum axle load of 25.4 tonnes.

[2] The EMGTPA value is obtained by multiplying actual annual tonnage of traffic by factors allowing for axle weight and speed.

57 The softwood longitudinal timbers on bridge 456 were over 10 years old. Anglia Route's asset management plan showed that bridge 456's timbers were due to be replaced in 2021. Hardwood timbers would normally be expected to last for at least 25 years.

58 A GRP (glass fibre reinforced plastic) walkway with a solid surface was installed on the up line between the longitudinal timbers on bridge 456 when the timbers were renewed in 2008. A similar walkway was installed on the down line across the bridge in 2018 during bridge refurbishment work.

Inadequate rail restraint

59 Evidence of inadequate rail restraint over a period of time is provided by Network Rail's track gauge measurements. The gauge across bridge 456 had exceeded the alert limit since at least June 2018 when static gauge of up to 1455 mm was recorded during a detailed inspection (paragraph 96), equivalent to wide gauge of 20 mm. Track recording vehicles had recorded dynamic gauge exceeding the intervention limit at about the same location since March 2019 (figure 13). The difference between static and dynamic gauge demonstrates that the track was flexible enough for the gauge to widen significantly under train loading. Issues associated with the management of track gauge are discussed at paragraph 95 onwards.

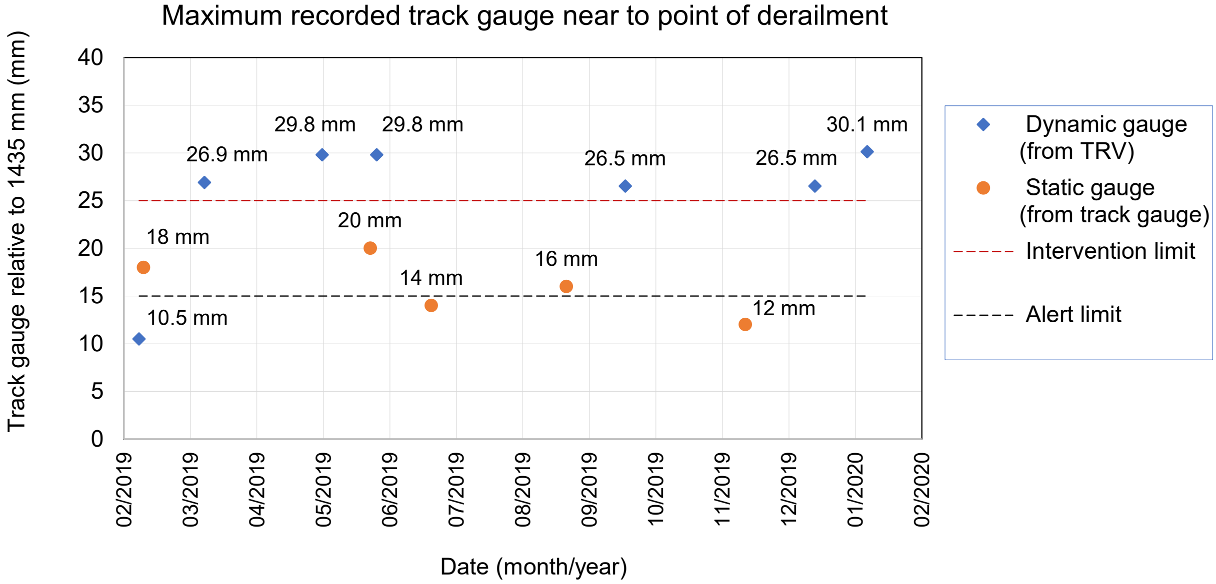


Figure 13: Maximum static and dynamic gauge recorded near point of derailment on each site inspection and track recording vehicle run.

60 RAIB took post-accident measurements on the bridge to determine if the stiffness of the track varied on approach to the point of derailment. A hydraulic ram was installed between the rails, and the pressure was increased in increments, creating spreading forces up to 50 kN (equivalent to 5 tonnes). This test was repeated at five locations across the bridge. The results show that the rails were less able to resist movement under the lateral forces imposed by moving trains as the point of derailment was approached (figure 14). These results are broadly consistent with Network Rail's track gauge measurements. However, it should be noted that accident damage meant that measured stiffness in the area of significant damage will be less than before the accident and, due to distribution of load along the rails, measured stiffness will also be lower than pre-accident values on the approach to this area.

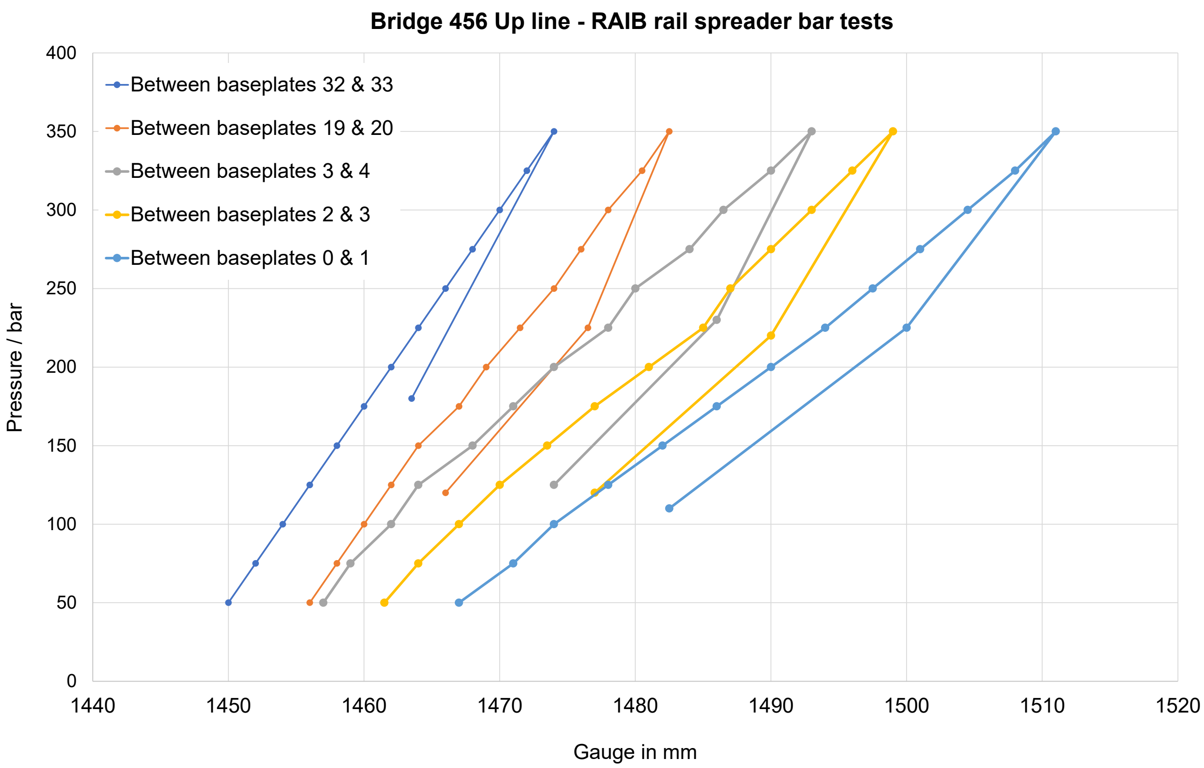


Figure 14: Change in track stiffness between baseplates. These were numbered from 34 at the start of the bridge to 0 at the point of derailment (POD1).

61 Further evidence of pre-accident track movement is provided by the right-hand rail's railhead profile, which varied in shape across the bridge (figure 15). A new rail is rolled to a constant profile, but the wear from passing train wheels, particularly on the outside rail on curved track, will gradually change this shape. The rail showed a relatively consistent amount of wear on the side of the railhead (sidewear), but a pronounced change occurred a few metres before the point of derailment. In this area, there was less sidewear, suggesting that lateral loads from train wheels caused the rail to move away from the wheel flanges. The consequential reduction in lateral force exerted on the outer rail by the wheel flange would have reduced the amount of rail wear.

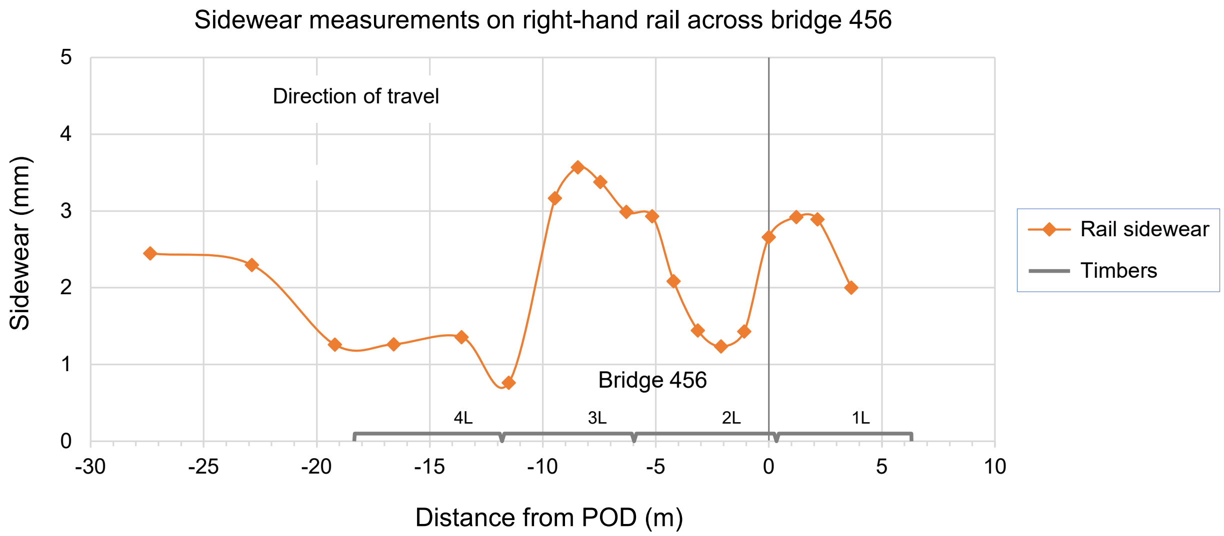


Figure 15: Change in rail wear

Timber deterioration

62 Following the accident, the up line longitudinal timbers were removed from bridge 456 in four panels, each panel comprising the left-hand and right-hand timber with the transoms and tie bars connecting them. They were taken to a secure site and laid out for examination by RAIB, an independent timber specialist commissioned by RAIB and Network Rail (figure 16 and figure 17). The panels were dismantled in controlled stages during the examination.

Figure 16: Longitudinal timbers laid out for examination following removal of the right-hand (six-foot) rail. Timber 2L is nearest the camera with 1L beyond it.

Figure 17: Timber 2L being cut into sections for examination

63 The section of timber 2L supporting the track at the point of derailment (figure 18 and figure 19) was cut into sections and examined. It was found to be saturated with water and extremely soft. A long probe was pushed into the wood at several locations without meeting resistance and part of the timber disintegrated while being moved during the examination. There was evidence of baseplate screw holes having been plugged and re-drilled, indicating that a previous attempt had been made to restore the track gauge at this location. This method of re-gauging can only be regarded as a temporary measure in softwood as there is often insufficient sound material to withstand the forces imposed.

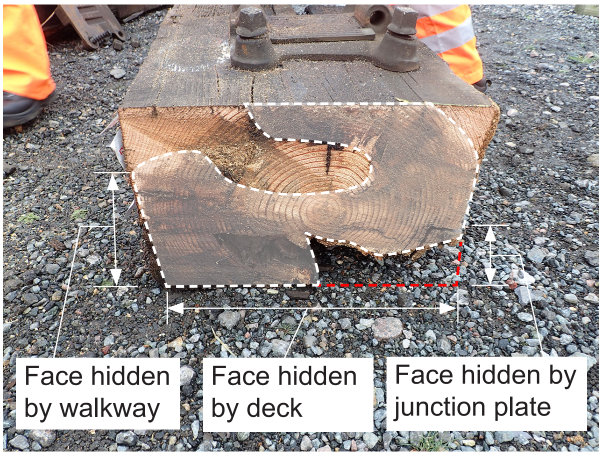


Figure 18: Section through timber 2L at the point of derailment. The area of decayed timber is indicated by the white dashed line.

Figure 19: Section through timber 2L immediately before the point of derailment

64 The section of Timber 1L (figure 20) immediately after the point of derailment had evidence of a longstanding corner fracture (split) and moisture ingress. This was in the area where the leading right-hand wheel of wagon 3415's trailing bogie was probably pushing against the rail (see paragraph 111) at the moment the trailing right-hand wheel derailed. The longitudinal fracture ran through the outermost baseplate screws. It is likely that this fracture was caused by lateral loads imposed by the screws and stresses associated with natural timber shrinkage around the screws.

Figure 20: Timber 1L before cutting, but following removal of the first baseplate beyond the point of derailment

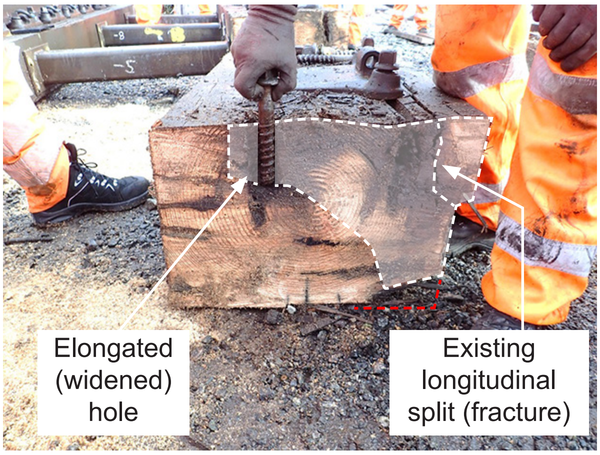


Figure 21: Timber 1L after cutting at the position of the first baseplate beyond the point of derailment. The area of decayed timber is indicated by the white dashed line.

65 The split in timber 1L had been identified and recorded during a detailed inspection in June 2019 (refer to paragraph 105). The post-accident examination found evidence of fungi growing within the wood indicating the presence of air. The presence of a split along the line of the large screws securing the rail baseplates meant that the outer row of screws became ineffective in securing the rail. The additional horizontal force applied to the inner row of baseplate screws had caused their holes to become oval shaped, as the metal screw pressed into the partly-decayed wood due to lateral loading from trains (figure 21).

66 The timber specialist's report included the following conclusions:

a. timbers 1L and 2L, adjacent to the derailment location, both had significant decay which would have severely reduced their integrity/structural capabilities

b. the extent of decay recorded in timber 2L for approximately 2 metres approaching the point of derailment was up to 70% loss of the cross section

c. the amount of decay in timbers 1L and 2L would have resulted in these timbers being at risk of deforming either permanently, or when loaded.

67 Laboratory examination confirmed that timber preservative was present on the surfaces, and to a depth of a few millimetres below the surfaces of timbers 1L and 2L. The heartwood, the dense inner part of the tree trunk which forms the majority of a timber section of this size, was not protected. The heartwood of Douglas Fir originating from North America and Europe is classified as 'extremely difficult to treat',[3] even under vacuum and pressure treatment cycles. Preservative treatments limited to near the surface of the wood can result in timber appearing superficially sound while deeper decay is hidden.

68 It is probable that the rot was partly a consequence of rust flakes collecting on the deck and trapping moisture around the base of the timbers. Evidence that this was occurring is provided by photographs taken during an inspection in June 2018 (figure 22). Some of this debris was removed during bridge strengthening and refurbishment works completed later that year. It is also probable that evaporation of water from the bridge deck and some faces of the longitudinal timbers was restricted by the solid walkway installed between the rails on the up line in 2008, which restricted ventilation (figure 5).

Figure 22: Photograph from detailed inspection report dated 7 June 2018 showing a restraining cleat and rust flakes on the bridge deck prior to deck refurbishment (courtesy of Network Rail)

[3] BS EN 350:2016 Durability of wood and wood-based products — Testing and classification of the durability to biological agents of wood and wood-based materials.

Lateral restraint to timbers

69 Lateral restraint for the longitudinal timbers was provided by cleats attached to the bridge deck and by the tie rod and transom (strut) arrangement described in paragraph 24. The timbers supporting the right-hand rail were significantly deeper than the timbers supporting the left-hand rail due to the need to allow a 75 mm cant on the curve (paragraph 28).

70 The height of the cleats retaining the right-hand rail timbers was less than 50% of the timbers' depth (figure 23). The combined effect of the cleat height and tie rod position was to leave the upper section of the timbers 4L-1L with no lateral restraint except that provided by transferring load downwards through the decayed timber. The tie rods connecting the timbers together to maintain track gauge were set horizontally. They passed through the left-hand timbers at mid-height, but consequently were below mid-height for the deeper right-hand timbers (figure 24).

71 A revision to standard NR/L2/TRK/3038 (issue 6) published in 2014, requires new or replacement cleats to be designed with a minimum height of not less than 2/3 the depth of the longitudinal bearer. Although this requirement was not retrospective, it gives an indication of the importance of the relative height of the cleats in restraining the timbers, particularly on curved track where the track is subject to lateral forces.

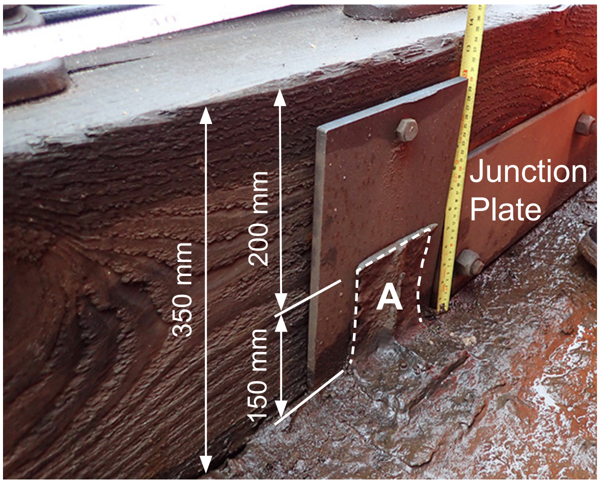


Figure 23: The position of a cleat (marked 'A') restraining timber 2L with a metal packing behind, and a junction plate connecting timber 2L to timber 1L

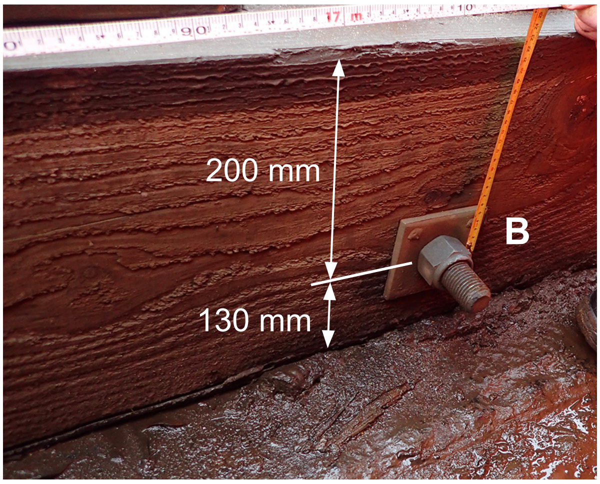


Figure 24: The position of a tie rod (marked 'B') restraining timber 2L

72 Junction plates connecting the timbers also extended for only part of the timbers' depth (figure 23). This meant that the outside plate connecting 2L and 1L provided no support to the upper part of the timber and this is a possible reason for the longitudinal split developing in this area. The combination of decayed timber and limited direct support from the tie rods and cleats, possibly exacerbated by the junction plate arrangement, meant that lateral loading from train wheels would result in relatively large movements of the right-hand rail.

73 The track's ability to resist gauge widening on bridge 456 is likely to have worsened when the vertical split in timber 1L joined up with a horizontal split, displacing a section of timber (figure 20). Some of the gauge widening forces which could not be resisted by timber 1L will have been transferred by the rail into the adjacent section of timber 2L which was already weakened by decay.

74 Track recording vehicles identified a wide gauge fault but output derived from this data did not result in track maintenance staff repairing faults at the correct location.

75 Track geometry data obtained from track recording vehicles (paragraph 29) is supplied to the TME responsible for each section of track. They are required by Network Rail standard NR/L2/TRK/001/mod11 to review this data within three weeks of issue. The data includes a trace, comprising a multi-channel graph showing gauge, alignment and other track geometry parameters.

76 Geometry faults which exceed the intervention limit are also listed, with their global positioning system (GPS) co-ordinates, on a track geometry action report. This is also known as an immediate action report or fault report. Network Rail states that these co-ordinates are accurate to ±1m, providing the track recording vehicle is able to receive a strong enough GPS signal. The signal can be restricted when a train is within a structure such as a tunnel or station. There are no features of this type at the accident site.

Evidence of track movement at bridge 456

77 RAIB has reviewed track recording vehicle data for the up line across bridge 456 from June 2018 onwards. On 20 June 2018, a dynamic wide gauge fault of 23 mm was recorded on bridge 456. This value was 8 mm greater than static gauge recorded at the same location during a detailed inspection on 6 June 2018 (paragraph 97), indicating that track movement was already occurring under trains. At this stage, the dynamic gauge fault remained below the intervention limit (25 mm).

78 Similar gauge faults were apparent on two subsequent track recording vehicle runs during 2018, but the run on 6 February 2019 indicated that the gauge had significantly improved, recording wide gauge of just 10.5 mm near the POD. However, the next run on 6 March 2019 recorded a wide gauge fault of 26.9 mm. Network Rail's central track geometry processing team compared this data with the previous recording on 6 February 2019 and declared the gauge data invalid for a 10 chain (201 metre) length of track which, by chance, included bridge 456. Consequently, the data was discounted and did not appear in the associated fault report so no action was taken. RAIB has identified that the February data was significantly different to previous recordings and may itself have been spurious.

79 On 1 May 2019, the next track recording vehicle run recorded a wide gauge fault of 29.8 mm in the same location, exhibiting a similar 'shape' to the data recorded on 6 March (figure 25). This was the first recognised indication of a gauge fault exceeding the intervention limit at this location, and was shown on the trace and listed on the fault report.

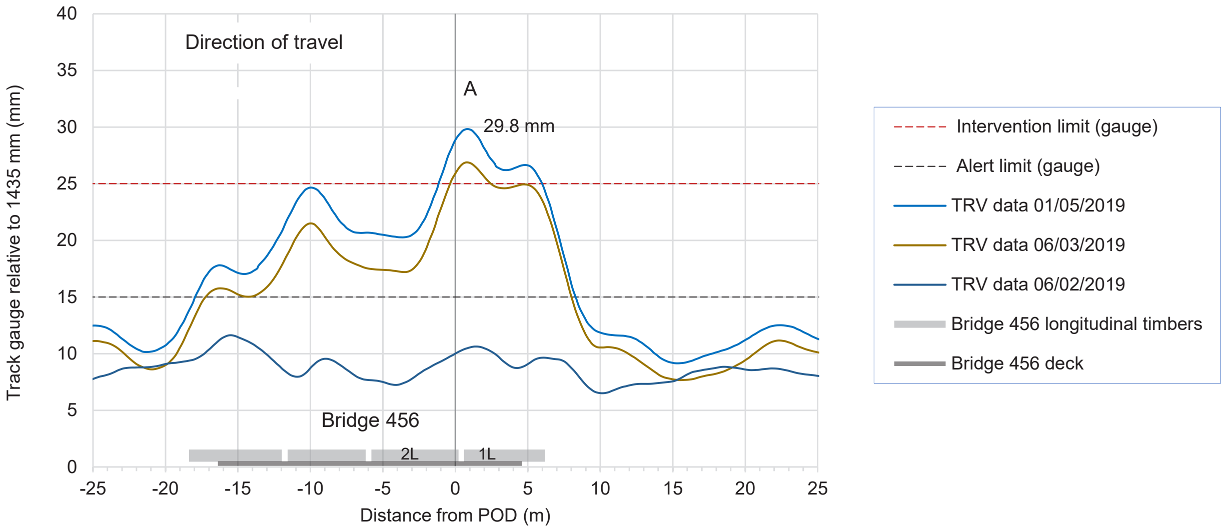


Figure 25: Track gauge recorded by track recording vehicle runs on 6 February, 6 March and 1 May 2019. The wide gauge peaks at the same location (marked 'A') close to the joint between timbers 2L and 1L and just ahead of the initial point of derailment.

GPS errors

80 On 23 May 2019, track maintenance staff from Barking depot, led by the team leader [track maintenance], attended site during an overnight possession of the line. The team leader stated that they used an approved app on a Network Rail mobile phone to locate the fault. This app works by manually entering the GPS co-ordinates, and this causes the phone to vibrate when within five metres of the site, and the display to change colour when within three metres, giving staff a three to five metre radius around the reported site to locate and inspect the fault. The process is dependent on the mobile phone's accuracy when receiving the GPS signal. In this case, although the GPS co-ordinates put the fault on bridge 456 (figure 26), staff undertook work about eight metres west of the actual fault location and on a section of track with concrete sleepers.

81 The team leader used a cross-level gauge to identify a section of track with wide gauge, and found nine concrete sleepers with crushed or displaced nylon insulation pads[4] supporting the right-hand (high) rail. Members of the team unclipped the rail, renewed the nylon pads and clipped the rail back up. When they rechecked with the cross-level gauge, it showed that the gauge was back within tolerance. The team leader signed a form to confirm that work had been undertaken, and under the heading 'Details of work carried out to repair the fault', wrote '*Regauged track*'. The team leader stated that he had a quick look at the longitudinal timbers on the bridge and measured the gauge but did not find anything to suggest a wide gauge fault that exceeded the intervention limit on the bridge.

82 On 29 May 2019, the next scheduled track recording vehicle run identified and recorded a wide gauge fault in the same location and same magnitude as on 1 May (figure 27). The shape of the graph indicated a very similar pattern of gauge widening. On this occasion, the GPS co-ordinates on the fault report put the location of the wide gauge fault just off the bridge.

[4] Pads are required to electrically insulate the rail from sleepers and clips, and are available in different sizes so they can be used to adjust the track gauge.

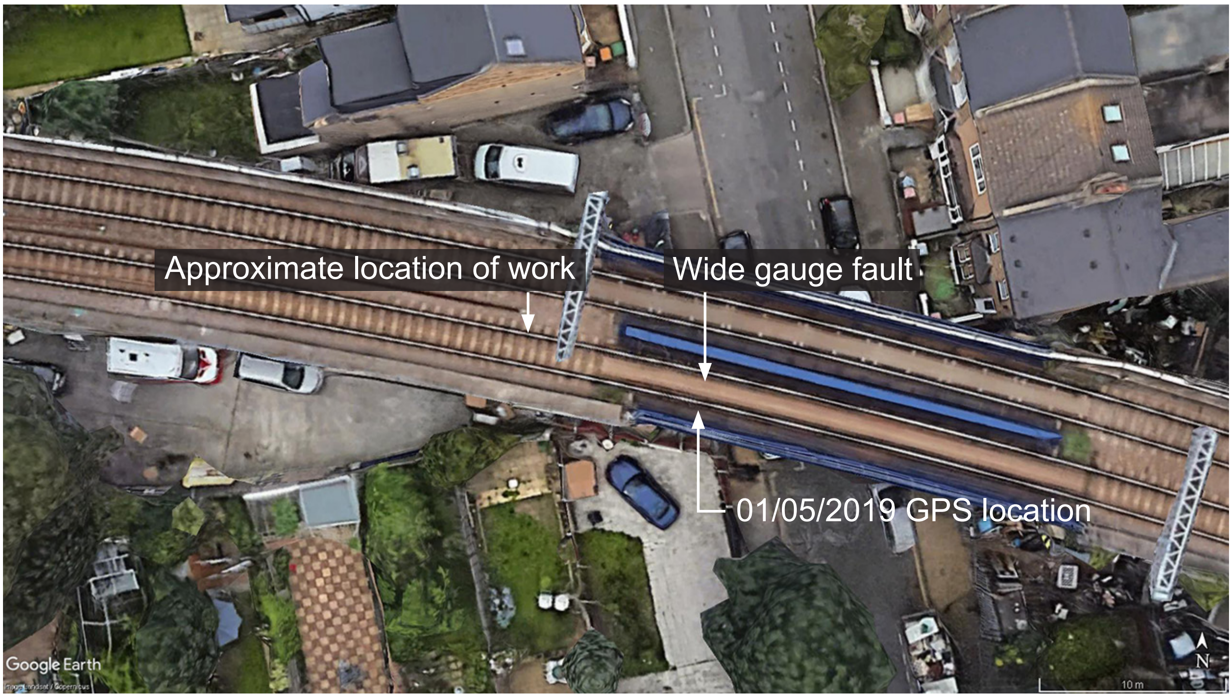


Figure 26: Google Earth image showing location of track recording vehicle-generated GPS co-ordinates and the approximate location that re-gauging work was carried out.

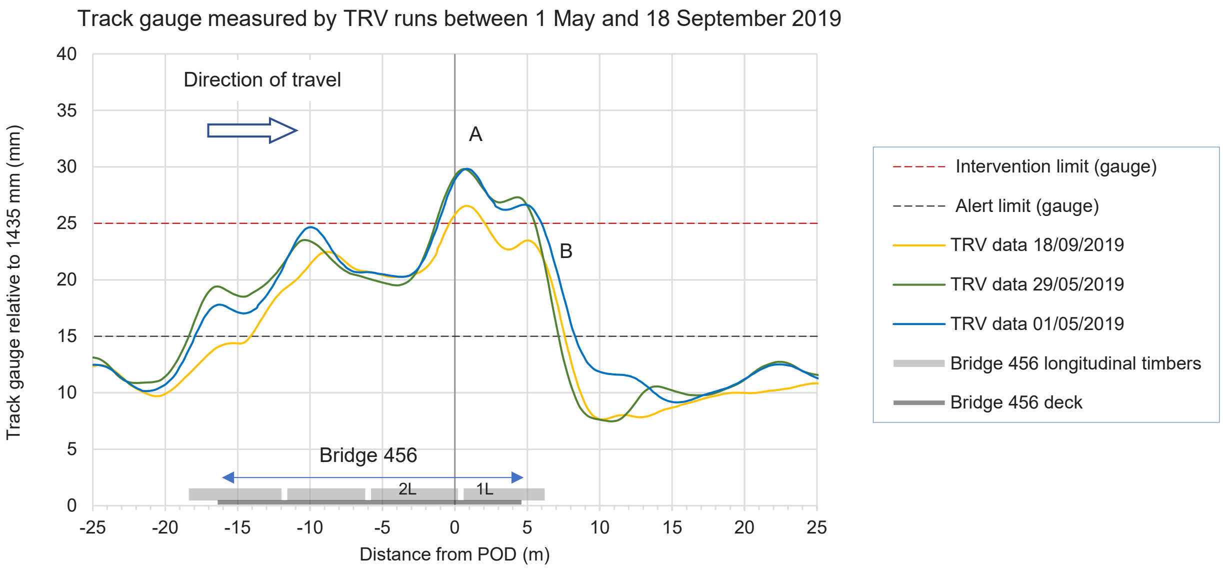


Figure 27: Track gauge data recorded by track recording vehicle runs on 1 May, 29 May and 18 September 2019. The graphs show that the gauge profile is a similar shape with a peak value (marked 'A'). Wide gauge exceeding the Alert limit is shown continuing off the bridge (marked 'B').

83 The Barking track maintenance team attended on 9 June and again used the mobile phone app to locate the fault using the GPS co-ordinates. They undertook work to the same section of track as on 23 May, but this time they renewed nylon insulation pads on the left-hand (low) rail, intending to correct the fault. The team leader again recorded 'Regauged track'.

84 On 18 September, the next track recording vehicle run identified a wide gauge fault of 26.5 mm in a similar location to the faults recorded on 1 May and 29 May. However, this time, the GPS co-ordinates printed on the fault report put the fault further off the bridge. A team from Barking depot attended on 29 September led by an assistant team leader. They renewed more nylon insulation pads on the concrete-sleepered track off the bridge.

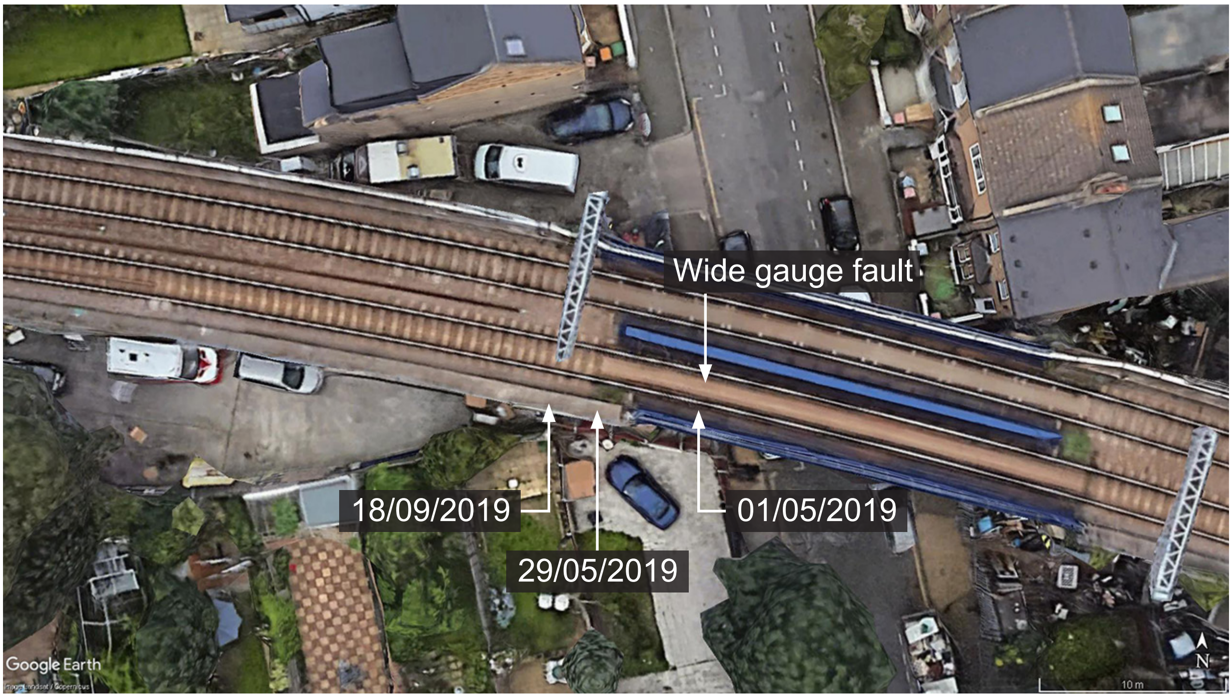


Figure 28: Google Earth image showing location of track recording vehicle-generated GPS co-ordinates compared with location of the wide gauge fault

85 Figure 28 shows the GPS co-ordinates for the gauge faults recorded on 1 May 2019, 29 May 2019 and 18 September 2019 plotted on Google Earth. The faults were recorded by equipment on different track recording vehicles and are up to 6.5 metres from the actual location of the wide gauge fault. Two of the locations are off the bridge on the concrete-sleepered track.

86 The range of co-ordinates recorded by different GPS units for the same track fault indicates that the GPS systems did not achieve the expected accuracy of ±1 metre (paragraph 76).

Hysteresis threshold for reporting faults

87 For the next two track recording vehicle runs on 11 December 2019 and 8 January 2020, wide gauge faults of 26.5 mm and 30.1 mm respectively were recorded on bridge 456. On both occasions, the fault exceeded the intervention limit (figure 29 and figure 30) but was missing from the associated fault report.

88 The same issue caused both omissions and is explained by an extract from the track recording vehicle trace for 8 Jan 2020 (figure 31). This shows wide gauge faults, automatically highlighted in red on the trace, corresponding with bridges 456 and 448 located within a section of continuous wide gauge. The wide gauge fault of 30.1 mm on bridge 456 is less severe than the wide gauge fault of 34.4 mm recorded on bridge 448.

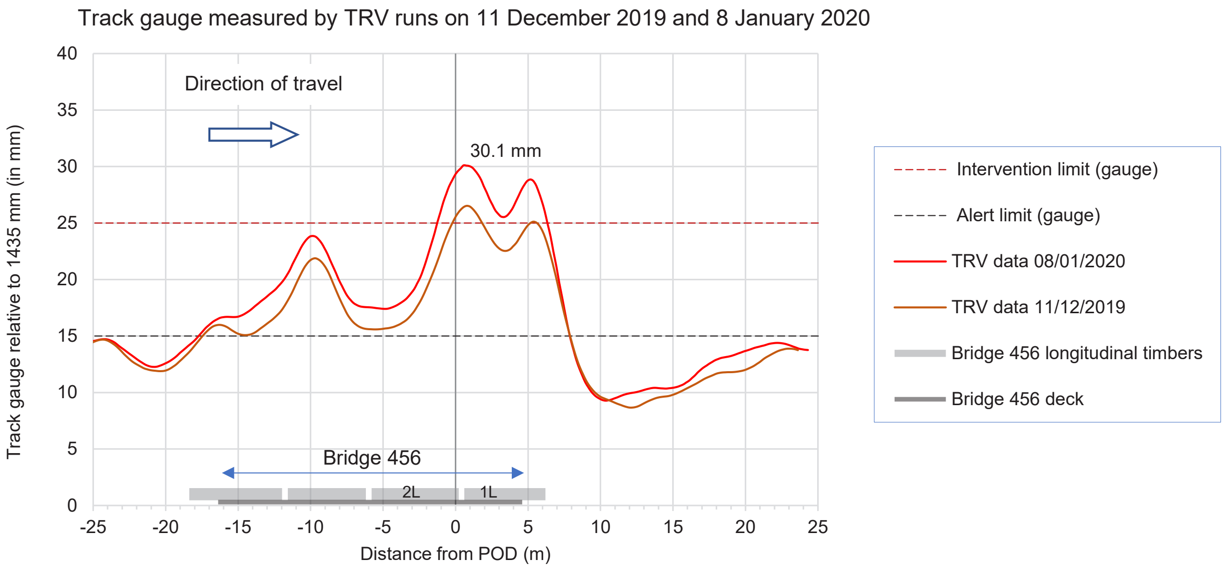


Figure 29: Track gauge data recorded by track recording vehicle runs on 11 December 2019 and 8 January 2020. The peak wide gauge fault value recorded on 8 January 2020 is indicated.

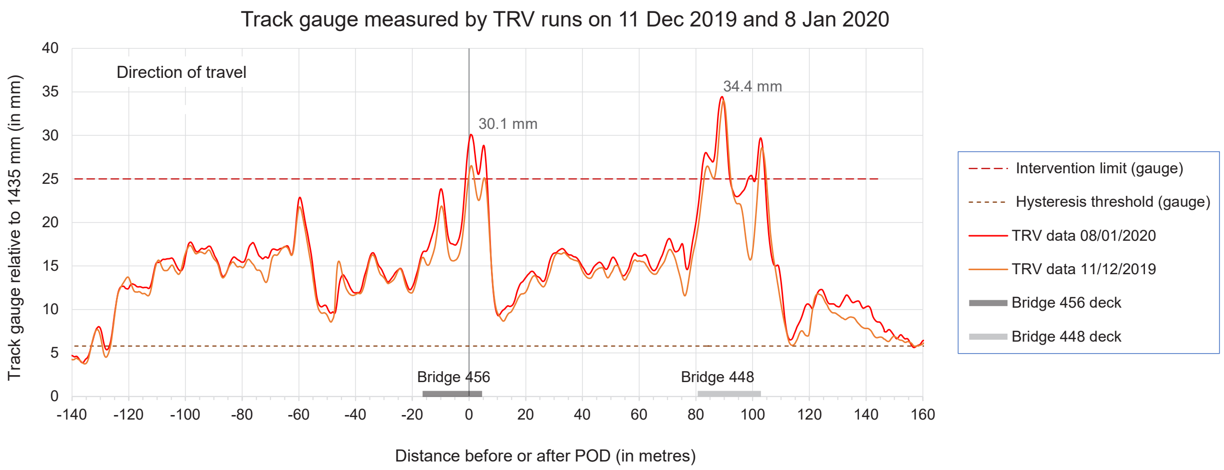


Figure 30: Track gauge data recorded by track recording vehicle runs on 11 December 2019 and 8 January 2020, but extending over a longer distance than figure 29. The peak wide gauge faults at bridges 456 and 448 on 8 January 2020 are indicated together with the hysteresis threshold.

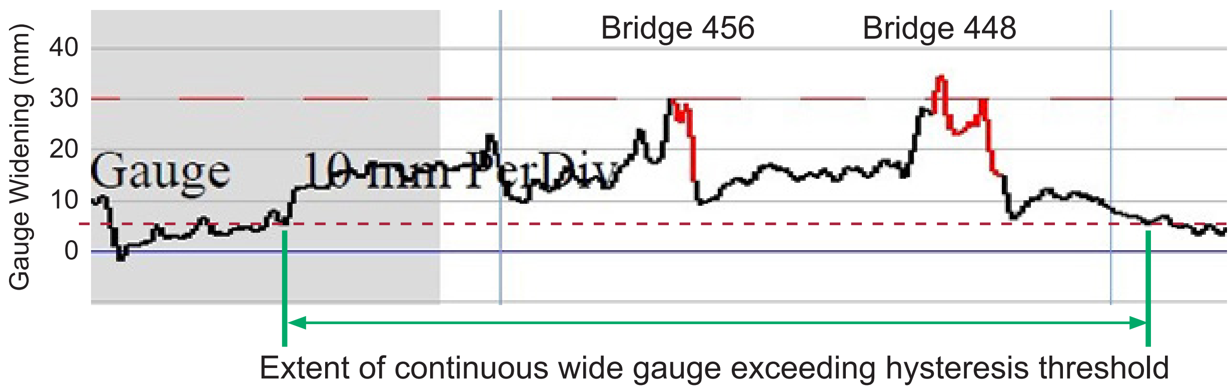


Figure 31: Extract from the track recording vehicle trace recorded on 8 January 2020 showing track gauge. Faults exceeding the intervention limit (25 mm) are automatically highlighted in red. The hysteresis threshold (5.8 mm) and the positions of bridges 456 and 448 have been added.

89 The TrueTrak recording system used by Network Rail's fleet of track recording vehicles incorporates a feature to provide a single GPS location for each track geometry fault. Fault sheets are produced following each run which show the type of fault detected, its magnitude and the GPS location where the fault is most severe. They do not show the distance over which the fault extends. To enable it to distinguish between consecutive faults, the processing software applies a pre-set quantity known as the hysteresis threshold value. The recorded magnitude of the fault must improve until it is better than this threshold for the system to register the end of one fault and the start of the next.

90 For wide gauge, the hysteresis threshold value was set nationally at 5.8 mm, equivalent to a gauge of 1440.8 mm. However, as gauge widening may occur over long sections of track, particularly on curves, only identifying the location and magnitude of the peak (widest) reading will have the effect of hiding other peaks within a length of track which continually exceeds the threshold.

91 On both 11 December 2019 and 8 January 2020, the hysteresis threshold value for gauge was exceeded continuously for a distance of about 240 metres on a section of track which included bridges 456 and 448. Consequently, this was reported as a single fault with a GPS location corresponding to the maximum recorded wide gauge which occurred at bridge 448. The lower peak on bridge 456 was not reported on either fault sheet and was therefore not addressed.

92 Gauge widening greater than the hysteresis threshold between bridges 456 and 448 probably occurred because of a combination of worn or damaged nylon insulation pads and rail wear. Network Rail has confirmed that this section of track did not require designed gauge widening.[5]

93 When the trace and fault reports were received by the TME following a track recording vehicle run, technical staff at Barking depot reviewed the trace and compared it with the previous trace. The purpose was to identify repeat faults and poor sections of track where intervention is required. Actionable faults which exceeded the intervention limit (also known as Level 2 faults) were reviewed at a regular maintenance planning meeting and entered into Network Rail's computerised workbank (Ellipse) so they could be monitored and closed-out when remedial work was complete. The TME did not consider that it was the responsibility of the depot staff to check that faults shown on the trace were included on the fault reports and there was no requirement to do so in the Network Rail procedure TRK/001 mod 11 'Track geometry - Inspections and minimum actions', issue 8 published in September 2015. However, if the review by depot staff identified an anomaly, this would be checked with the central track geometry processing team and, if necessary, the fault would be added to the Ellipse work bank for correction.

94 The data from the track recording vehicle run on 8 January was received by the TME on 15 January. At the time of the accident, the technical review was ongoing in preparation for a maintenance planning meeting scheduled for 23 January (the day of the accident).

[5] Track gauge is sometimes deliberately designed to be a few millimetres wider than 1435 mm on tight curves to reduce rail wear.

95 Network Rail was not aware of the severity of the longitudinal timber degradation and so took no action to deal with this.

The inspection process

96 On 6 June 2018, the team leader [longitudinal timbers] for Barking depot undertook an annual detailed inspection of the timbers supporting the up line on bridge 456. This was a role for which he had received specialist training and which he had undertaken for six years. He was responsible for inspecting 21 structures, most of which comprised two individual spans and which incorporated 282 individual timbers.

97 Although the team leader was not undertaking a scheduled Supervisor's visual track inspection, he used form TEF3021 'Supervisor's Visual Inspection of Longitudinal Timbers – Issue 6 Sept 2013' to record static gauge readings at 12 positions across the bridge, as there was nowhere to record this information on the detailed inspection form itself. His report indicates that the static track gauge ranged between 1445 mm and 1455 mm, equivalent to wide gauge of 10 mm to 20 mm. As the static gauge exceeded the alert limit of 1450 mm, equivalent to wide gauge of 15 mm, at several locations towards the middle of the bridge, he recorded '*adjust gauge*' on this form.

98 He also used form TEF3014 'Detailed Inspection of Longitudinal Timber System report – Issue 5 Dec 2010' to record the detailed inspection. He noted that timber 2L was in '*good*' condition, but that there was a 300 mm long split at the end of the timber where the derailment occurred. He recorded that timber 1L was in '*fair*' condition with rot starting at the end furthest from timber 2L. He also identified that the plate decking was corroding, with debris on the bridge. He assessed that all the timbers on the up line had five years' remaining life. On the final page, he recorded '*Some of the timbers are starting to show signs of deterioration on the up road* [up line] *so life span has been reduced.*'

99 The GRP walkway fitted between the timbers had not been removed as required by standard TRK/3038 (issue 6), so the team leader was unable to view the inside faces of the timber. Clause 8.2 which covers the annual detailed inspection states:

> '*Where walkway boards prevent inspection of significant elements of the longitudinal timber system e.g. cleats, transoms and tie rods, the boards shall be removed to allow inspection.*'

100 The team leader recorded '*Underside of timbers not inspected*' and '*Inside of timber not accessible due to fibre glass walkway*' in his report.

101 The presence of fixed walkways was an ongoing issue at four spans on the Barking to Gospel Oak line where there were walkways installed, including bridges 456 and 448. The team leader stated that walkways were never removed for inspections (figure 32). The walkway on bridge 456 had been installed to assist staff walking along the track, but as the bridge was located on a section of track where access was prohibited except during a possession or line blockage, it was rarely used. As there was insufficient time during a possession to remove/reinstall the walkways and complete a detailed examination, the TME planned to have the walkways removed permanently during 2020.

Figure 32: View of bridge 456 deck following the accident, but before the walkway was removed. With the walkway in place, the inside faces of the longitudinal timbers were not visible for inspection.

102 In December 2018, the TME visited bridge 456 during a planned two-yearly track maintenance engineer's inspection. He observed and recorded a split in a longitudinal timber on the down line, but did not observe anything amiss with the track or any of the longitudinal timbers on the up line. The first indication of a wide gauge fault was not apparent until three months later (paragraph 78).

103 In March 2019, the acting team leader [longitudinal timbers] took over responsibility for detailed longitudinal timber inspections for Barking depot. On 19 June 2019, he undertook an annual detailed inspection of bridge 456. He used form TEF3021 to record the gauge which ranged from 1448 mm to 1453 mm, equivalent to wide gauge of 13 mm to 18 mm, and was 14 mm near the POD. The gauge exceeded the alert limit but remained below the intervention limit and he recorded '*adjust gauge*' on the form.

104 During the detailed inspection he stated that he checked for damage, loose screws, and large splits but found nothing loose. He was unable to inspect the inside of the timbers and reported '*inside of timber not accessible due to fibre glass walkway*'. He also identified that 12 cleats were corroding and wrote 'New cleat system required.'

105 He identified a split in timber 1L and observed that part of the timber was out of alignment. He recorded '*15mm split*' in the relevant part of the TEF3104 report and included three photographs of the split in his report (figure 33 and figure 34).

106 In answer to the question ‘what method did you use to test timber integrity’, the report states ‘*hammer and drill*’. The report does not record which timbers were tested, but the acting team leader [longitudinal timbers] did not identify decay within timbers 1L or 2L. Standard TRK/3038 (issue 6) states ‘*Test drillings of timber shall only be taken when there are signs of deterioration or other grounds to suspect decay of the timber.*’ The photographs show that the visible faces of timber 2L showed no sign of the interior deterioration. This was probably because of the effect of the timber preservative (paragraph 67).

107 The acting team leader had not reviewed a copy of the most recent track recording vehicle trace prior to commencing his inspection, despite his training telling him that he should do so (paragraph 134). He was therefore unaware that during the previous month, two track recording vehicle runs had recorded wide gauge faults on, or near, the bridge (paragraphs 79 and 82).

Figure 33 and figure 34: Views of 15 mm wide split in timber 1L recorded in the detailed inspection report dated 19 June 2019 (courtesy of Network Rail). The same split is visible in figure 20.

108 The acting team leader ticked ‘No’ to the questions ‘Is there any lateral and/or vertical movement Under Load’ and ‘Is there any sign of gauge spread’. He also reported that drainage was ‘G’ (i.e. Good) and marked Timber 1L condition as ‘Fair’, and Timber 2L condition as ‘Good’, with 4 years’ serviceable life remaining on all timbers. He did not add any comment on the final page of the report headed ‘General observation & Recommendations’ because he considered it would be repeating information in the body of the report. On 3 July 2019, the TME signed off both the TEF3021 and TEF3014 reports without adding any comments. The TME stated that it was difficult from a photograph to know the severity of the split and there was nothing that brought his attention to the split being a concern.

109 The assistant track manager undertook planned supervisor’s visual inspections of the longitudinal timbers on 8 February, 23 May, 22 August and 10 November 2019. On each occasion, he measured the static gauge (figure 13) and recorded this on a TEF3021 form. In the vicinity of the POD, gauge measurements ranged between 1455 mm (equivalent to 20 mm wide gauge) on 23 May 2019, and 1447 mm (equivalent to 12 mm wide gauge) on 10 November 2019. He marked the timber condition ‘Fair’ for all eight longitudinal timbers on the up line on each occasion.

110 On the report for the 22 August 2019 inspection, the supervisor wrote '*timber gauge job*' with a reference number. This referred to a work order to correct the wide gauge fault that had been raised in Ellipse on 25 July 2018 following the note added to the detailed inspection report the previous month (paragraph 97). However, this activity had been repeatedly reprioritised and the work deferred because site reports and inspections indicated that the gauge was not deteriorating and had not yet exceeded the intervention limit. The TME also understood that the previous five track recording vehicle runs had shown there were no gauge faults on the bridge, and that the gauge faults that were shown related to the concrete sleepers near the bridge with crushed nylon pads where remedial work had been undertaken (paragraph 81). Although there was an established process for raising queries, the TME did not consider it was his team's responsibility to cross-check the centrally-produced fault sheets against the traces for errors or omissions.

111 The condition of the trailing bogie on wagon 3415 imposed unusually high lateral loading on the track.

112 The curving behaviour of conventional rolling stock means that significant lateral track forces are normal when trains negotiate small radius curves. However, the presence of unusually high lateral forces applied to the track by the trailing bogie of wagon 3415 is suggested by the following six wagons not derailing when travelling over the position where the bogie derailed (the leading bogie of wagon 3114 derailed beyond this position). This implies that the rails on the curve spread outwards as the trailing bogie of wagon 3415 travelled past, and moved back before the remaining wagons passed. Damage to bridge timbers (paragraphs 62 to 73) indicates that most of the spread was due to movement of the right-hand rail. It is possible that the trailing bogie applied unusually high lateral forces because of a combination of the following two factors:

- a defect on wagon 3415 (paragraph 113)
- uneven payload (paragraph 124).

Defect on wagon 3415

113 Evidence that wagon 3415's trailing bogie was imposing a high lateral force (figure 35) on the right-hand rail is provided in the following paragraphs by considering wheel flange wear over the previous three years. Curving behaviour under cant excess suggests that the right wheel flange of the trailing bogies of each wagon would have been close to, and probably in contact with, the outer (right-hand) rail (paragraph 46).

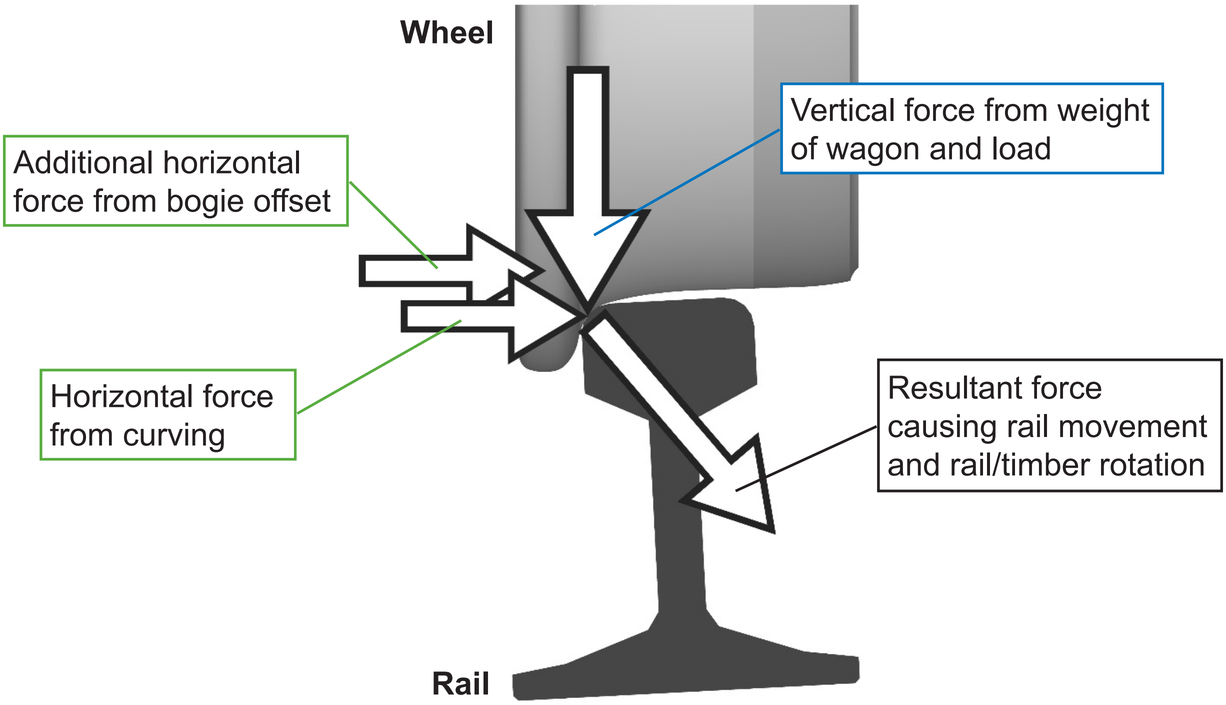


Figure 35: Simplified diagram showing forces acting from wheel to rail to cause rail movement and rotation

114 The corners of the wagon are numbered 1 to 4 in a clockwise direction (as seen from above). On 23 January 2020, the 2-3 end of the wagon was leading so the trailing bogie was at the 1-4 end of the wagon. Analysis of maintenance records provided by the wagon's owner, VTG, shows that wagon 3415 was removed from service in November 2017, August 2018 and September 2019 because its wheel flanges had worn thin and were approaching the wear limit. For wheels with the P6 profile, as fitted to this wagon, the minimum permitted flange thickness is 24 mm. On each occasion, the significant flange wear had occurred to the wheels fitted to the 1-4 end bogie, but only affected one wheel on each wheelset. Records do not show whether this was the left-hand side or right-hand side. On each occasion, two full profile wheelsets were fitted to the 1-4 end bogie before the wagon re-entered traffic. VTG's Wheel Exchange Authorisation forms show that throughout this time, the wheelsets on the 2-3 end bogie experienced normal wear and were not changed.

115 The most recent wheelset change took place in October 2019. Following the derailment on 23 January 2020, wheel measurements showed that the right-hand flanges on the two wheelsets fitted to the 1-4 end bogie were at least 2 mm thinner than those on the left-hand wheels, despite having been in service for less than four months. This unusually high wear is consistent with the right-hand wheels of this bogie running for longer in flange contact with the rail than the left-hand wheels.

116 A detailed inspection of the 1-4 end bogie, undertaken by RAIB before the wagon body was lifted from the bogie, found that the bogie centre pivot, provided to allow bogie rotation when the wagon goes around curves, was offset by 7 mm to the right of the wagon body centre-line. This suggested an issue with the bogie pivot so RAIB and VTG carried out further examinations of this centre pivot, and the 2-3 end bogie centre pivot, after the body was lifted from the bogies.

117 To permit bogie rotation, the top of each bogie is fitted with a bogie centre pivot with an internal diameter of 17 inches (432 mm) (figure 36). This encloses and supports a slightly smaller top centre pivot fitted to the underside of the wagon's underframe (figure 37). The two parts are designed to allow a radial clearance of approximately 6 mm between each of the vertical faces within the assembly. This is to allow the bogie to move laterally into the appropriate position relative to the wagon body. The large horizontal surfaces of these steel castings are designed to be in contact and support the weight of the wagon body in conjunction with side bearers.[6]

Figure 36: The 1-4 end bogie and bogie centre pivot after removal from wagon 3415

Figure 37: The 2-3 end top centre pivot with pin, located on the underside of the wagon's underframe

Figure 38: The 1-4 end bogie centre pivot on wagon 3415

Figure 39: The 2-3 end bogie centre pivot

118 Examination of the bogie centre pivot attached to each bogie found a difference in the wear patterns, with uneven contact apparent on the 1-4 end, but relatively uniform contact on the 2-3 end (figure 38 and figure 39).

[6] A component located on the side frame of a bogie (one per side) which provides vertical support to the vehicle body while allowing the bogie to rotate.

119 The bogie centre pivots incorporate a central upstand, 40 mm high and 108 mm diameter with a 63 mm diameter hole to contain a pin. The upstand fits into a recess in the top centre pivot. On the 2-3 end, the top centre pivot recess measured 43 mm deep, into which the 40 mm high upstand could fit without making contact at the top when the large horizonal faces of the castings were in contact. On the 1-4 end, the recess was also 43 mm deep, but it contained a 5mm thick plug of hardened debris-impregnated grease which had the effect of reducing its depth to 38 mm (figure 40 and figure 41). The grease plug pressed against the top of the upstand and carried part of the load intended to be carried on the large horizontal faces. This prevented the bearing from being correctly seated on the horizontal surfaces (figure 42 and figure 43).

Figure 40: Part of the grease plug extracted from the 1-4 end top centre pivot recess on wagon 3415

Figure 41: The largest piece of metal debris extracted from the 1-4 end top centre pivot recess

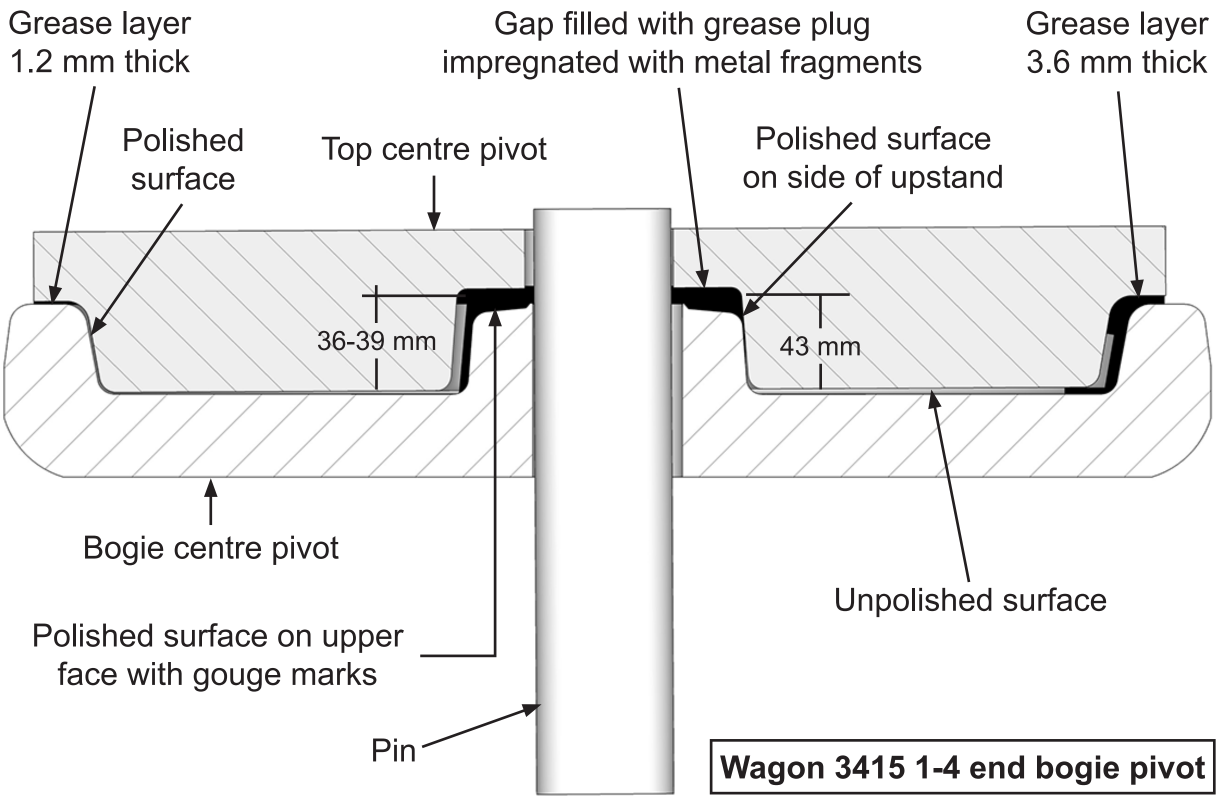


Figure 42: Diagram showing the wrongly seated 1-4 end (left) bogie centre pivot on wagon 3415

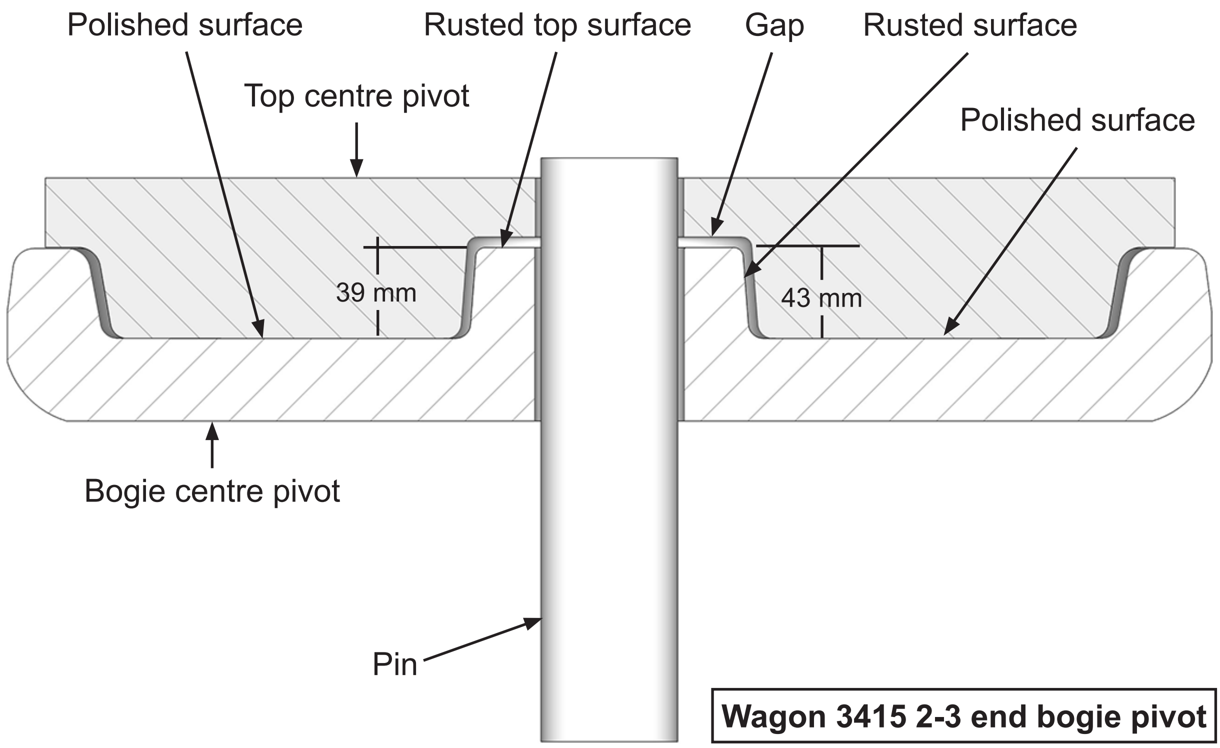


Figure 43: Diagram showing the correctly seated 2-3 end bogie centre pivot

120 Part of the recovered grease plug was tested by RAIB to determine the maximum compressive force the material could withstand. Samples of the grease were formed into 12 mm diameter x 4.7 mm thick pellets and placed into a testing rig which restricted lateral expansion. A force of up to 60 kN (6,000 kg) was applied and the amount of compression measured and recorded. A series of samples were each able to support a load of at least 170 N/mm^2 before the grease started to break down and flow. The test rig reproduced loading conditions that were similar to those that the grease plug was subject to when constrained in the bogie pivot. As the top of the central upstand has a surface area of approximately 6,000 mm^2, the grease plug would have been capable of carrying the weight of one end of a fully loaded wagon body.

121 When the bogie was installed, the grease would have been of a normal viscosity and would have flowed relatively freely. Grease contains oil and a thickening agent, but on examination, the grease had lost the volatile compounds of the oil, and gained some debris. This had resulted in it gradually hardening to form the plug found in the recess.

122 The source and role of the three pieces of metal debris in the grease plug is uncertain, but they may have formed as a result of earlier repair work. It is possible that the metal debris had played a part in transferring part of the wagon body load into an off-centre position on the upstand, so encouraging an uneven build-up of dried grease to one side of the pivot. This could have been enough to bias the bogie to one side and/or to restrict its free movement.

123 This wagon defect is considered to be a factor, since the resulting restricted bogie movement possibly explains the uneven flange wear on the right-hand wheels of the trailing bogie on wagon 3415 and the abnormally high forces that would be associated with this. The defect is not considered sufficient in itself to have resulted in the lateral loading needed to cause the derailment. This is evidenced by the same bogie passing over bridge 456 without derailing on nine previous occasions in the same month (paragraph 19).

Uneven payload

124 The wagons of train 6Z54 had been weighed when they arrived at Barking for loading, and again after they were loaded on 23 January 2020. On both occasions, the weighing equipment recorded the weight of each wheel. Weighing on arrival allowed the amount of residual payload from previous journeys to be taken into account when determining the maximum amount of material which should be loaded at Barking. Prior to loading on 23 January 2020, the average residual payload in each wagon was about 6.6 tonnes and the maximum was 13.5 tonnes.

125 The wagons were loaded at Barking using a 360° excavator with a weighing facility, working from the right-hand side of the train. This method of loading, and the nature of the clayey material involved, contributed to the payload in every wagon being off-set towards the right-hand side when the train left Barking on 23 January. Wagon 3415 did not exceed the maximum gross vehicle weight, but the load was concentrated towards the rear right corner of the wagon. The load on the leading and trailing wheelsets on the trailing bogie weighed 26.4 tonnes and 25.95 tonnes respectively, both exceeding the 25.4 tonne RA10 limit (paragraph 56). In addition, the payload was off-set so that the two right-hand wheels on this bogie were carrying over 6 tonnes more than the left-hand wheels with a maximum wheel load of 14.9 tonnes, which can be compared to the 12.7 tonnes carried if the maximum permitted vehicle load is distributed equally between all wagon wheels (figure 44). The maximum wheel load is also defined by Railway Group Standard GMRT2141 ‘Permissible track forces and resistance to derailment and roll-over of railway vehicles’ as not exceeding 124.5 kN. This is equivalent to a wheel load of 12.7 tonnes.

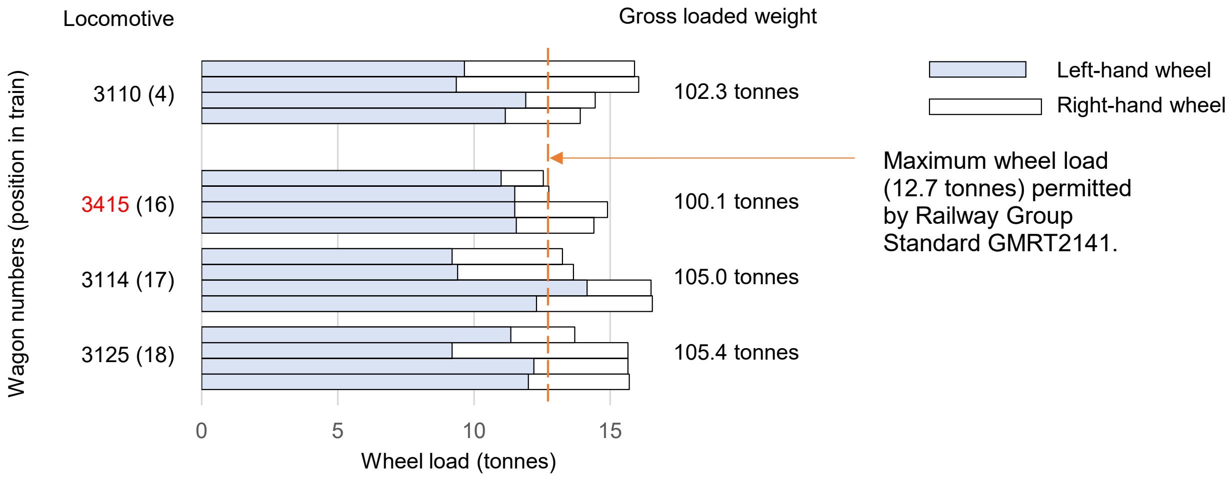


Figure 44: Wagon loading

126 Industry guidance[7] published by the National Freight Safety Group includes the following advice under the heading 'Bulk load distribution':

> *'Wagons when fully loaded or otherwise are required to operate within parameters of weight distribution. Unbalanced wagons change the ride characteristics of a wagon and are likely to have a greater propensity to derail. As a general rule the more evenly loaded from side to side and end to end the lower the risk.*
>
> *The side to side placement of the load should be controlled and monitored… In practice parties should target for balanced loading and manage their activities to reduce the potential inadvertent bias generated from loading activities. This can be achieved by monitoring the performance of their activities (visual or weights recorded) and providing feedback to the staff undertaking the load placement, identifying actions to be taken. The load placement process may require redesign if staff are unable to adjust loading to within the parameters.'*

127 RAIB has also analysed wagon loading data for the three preceding journeys. On three of the four occasions including 23 January, all wagons were more heavily loaded on the right-hand side. The recorded weight exceeded 12.7 tonnes for 89% of the wheels on the right-hand side of the train on 23 January. Over the four journeys, the average was 80%.

128 The magnitude of the payload and its unevenness would have affected the vertical loads on the bogie pivot assembly and the side bearers and, as a result, the horizontal friction forces acting at each of the various associated contact points and surfaces. It is possible that this combined with the behaviour of the defective bogie pivot arrangement to exacerbate the restriction on bogie rotation, thereby further increasing the lateral forces on the rails.

Underlying factors

129 Network Rail's inspection and maintenance processes were insufficiently rigorous to identify timber deterioration before an unsafe situation developed.

130 Network Rail manages and monitors the safety of its longitudinal timber assets by a combination of timber inspections by trained staff, data provided by track recording vehicle runs, and planned track inspections.

131 The acting team leader [longitudinal timbers], who undertook the detailed inspection in June 2019 (paragraph 103), had attended and passed an 'Inspection & Maintenance of Longitudinal Timber' training course in January 2019. Delegates attending this course were required to have already attended a supervisor's visual inspection course to enable them to recognise signs of track movement and interpret track geometry traces produced following a track recording vehicle run. The acting team leader had attended and passed this course in November 2018.

[7] National freight safety group code of practice 'Loading bulk wagons' NFSG-COP-004 published July 2019.

132 The longitudinal timbers course was run by an experienced Network Rail trainer. The course materials provided an extensive overview of the issues associated with inspecting and maintaining longitudinal timber systems. The two-day course was intended to be entirely classroom-based and the syllabus did not include any practical elements. There was no structured opportunity for delegates to look for rot, wear or damage, and there was no opportunity to practice testing techniques such as assessing the internal condition of timber by taking drill samples and sounding with a hammer (listening to the noise made when striking the timber with a hammer). The training was not specific on where or how inspectors should drill into timbers to detect decay.

133 Inspectors are required to assess the remaining life of the timbers, but this is a very subjective assessment - not easy to teach without practical elements, and dependent on variables including the amount of rail traffic, wheel loadings and track geometry. The training course included advice on looking for visual signs of failure starting, although these can be hard to identify in softwood such as the Douglas Fir used on bridge 456. Assessing the remaining life of a softwood timber was not specifically covered by the training. Some assets, such as earthworks, use a scoring system to assess asset condition, but there is no similar system for longitudinal timber inspections.

134 Delegates were instructed that they should obtain and review background information, including recent track recording vehicle traces, prior to an inspection.

135 The training course referred to use of the TEF3014 form (paragraph 98), but there was no guidance on how to complete the form and no guidance on whether the timber grading (Good/Fair/Poor) should apply to the whole timber or to its worst part. The course did not refer to the importance of completing the comments and recommendations section of the report to guide those responsible for reviewing it.

136 The techniques available to Network Rail timber inspectors seeking to determine the internal condition of timbers were limited to sounding with a hammer and taking drill samples. For timbers of this size, the effectiveness of a hammer test is limited, as a timber that made a hollow sound when hit would already be in an unsafe condition.

137 The drill provided to inspectors formed relatively large holes with the potential to introduce water, and so encourage rot, in the inner parts of timbers. Standard NR/L2/TRK/3038 (issue 6) therefore limited the use of drills to instances where there were signs of deterioration or other grounds to suspect decay of the timber. As demonstrated at bridge 456, timbers appearing to be in good condition can have a good surface concealing a rotten core (paragraph 67).

138 The timber specialist commissioned by RAIB to inspect timbers from bridge 456 (paragraphs 62 and 66) concluded that the internal decay in timbers 1L and 2L should have been detected by an effective inspection regime. The training given to longitudinal timber inspectors and the techniques available to them when undertaking inspections were likely to be insufficient to achieve this.

139 VTG’s processes did not recognise an underlying problem with wagon 3415 despite the unusual distribution and rate of flange wear on some of its wheelsets.

140 The need for frequent replacement of some wheelsets on wagon 3415 and the nature of wheel wear on the trailing bogie provided VTG with an opportunity to recognise a problem requiring consideration as a possible safety issue. However, the problem was not identified and so VTG did not consider the underlying cause and its possible implications for safety.

141 VTG stated that it did not have any specific process for monitoring or identifying unusual wheel wear patterns. Instead, it relied on the vigilance of the organisations responsible for maintaining the wagons or supplying the wheelsets to identify wear patterns which might indicate a significant geometry fault. VTG provided records of wear patterns for wheelsets fitted to other wagons in the same train, and RAIB found no other examples of wheel wear occurring as rapidly as on wagon 3415.

142 VTG also stated that uneven wheel flange wear can occur on wagons fitted with 3-piece bogies, such as those fitted to wagon 3415. The wear often occurs when the bogie needs to steer on sections of track with small radius curves and no flange lubrication, such as in sidings. Spilt sand and aggregates collecting on the track in loading areas can also contribute by grinding the wheelset flanges against the rails.

143 Although uneven wheel flange wear is not unusual, significant wear on two wheels on the same side of a bogie does appear to be so. Wheel wear data provided by VTG for most of the other wagons on the train, measured following the accident, showed a variation in flange wear of up to 3 mm when other wheels on the same wheelset were compared. However, only wagon 3415 exhibited rapid flange wear on the same side of both wheelsets on the same bogie.

Observation

144 Three wagons on train 6Z54 exceeded the maximum permitted weight.

145 Wagon wheel weights measured after loading on 23 January 2020 (paragraph 125) were used by loading staff to calculate the total weight of the train, and this weight was passed to a member of DB Cargo staff at Barking. They informed the DB Cargo TOPS office by phone who entered the train’s details into TOPS (Total Operations Processing System) which is operated by Network Rail for purposes including assisting management and recording freight train operations. TOPS carried out some checks before providing output indicating that the train was permitted to leave the loading facility. As only the total train weight had been provided, TOPS calculated the average weight per wagon, checked that this was within the permitted limit, and released the train for departure.

146 On 23 January, train 6Z54 departed from Barking with a total gross weight of 2167 tonnes excluding the locomotive. The maximum theoretical weight for the 22 wagons of train 6Z54, each at the maximum permitted weight of 101.6 tonnes, was 2235 tonnes and TOPS released the train on this basis. However, the train was released with three overweight wagons. These were wagons 3114 and 3125 positioned directly behind wagon 3415. These weighed 105 tonnes and 105.45 tonnes respectively, with the weight concentrated towards the trailing bogie in both cases (figure 44). The other overloaded wagon was the fourth in the train and weighed 102.35 tonnes. All three overloaded wagons were of the JXA type which are larger vehicles (paragraph 17) and therefore may have appeared to be less full. These three wagons were each carrying a residual payload of at least 10 tonnes on arrival at Barking (paragraph 124). Despite only three wagons exceeding the 101.6 tonnes gross weight limit for RA10, uneven loading meant that 24 of the 88 individual axles (27%) had loads in excess of 25.4 tonnes, and 82 of the 176 individual wheels (46%) had loads in excess of 12.7 tonnes (paragraph 125).

147 An alternative way to enter train data into the TOPS system, is to input the total weight of each individual wagon. Had this been done on 23 January 2020, TOPS would have prevented the train from being released because three wagons exceeded the maximum permitted weight of 101.6 tonnes (paragraph 18). The total weight of wagon 3415 was 100.15 tonnes and was not sufficient for TOPS to prevent the train commencing its journey. Network Rail has stated that it does not mandate that weighbridge weights for each wagon are entered into TOPS, but if overloading is identified, the wagons should be returned to the terminal to allow product to be removed.

148 For the journeys on 18, 21 and 22 January, only one wagon in each train exceeded the 101.6 tonne gross laden weight limit. However, uneven loading meant that an average of 26% of individual axles exceeded the 25.4 tonne maximum axle weight limit (paragraph 56).

Previous occurrences of a similar character

Derailment of a freight train at Bexley, 4 February 1997

149 A freight train derailed on Bridge 799, immediately east of Bexley station in south-east London, because of lateral movement of the track on the longitudinal timbers on the bridge and a resultant widening of the track gauge. The derailment resulted in substantial damage to the viaduct carrying the track. Four members of the public who were working in or near the arches under the viaduct were injured.

150 The investigation by HM Railway Inspectorate[8] found that the 12th wagon in the train was substantially overloaded. It derailed but remained upright. This resulted in the forces exerted on the track being on average larger than normal. The train was travelling in excess of the speed limit specified for freight trains on the route. The investigation also found that the longitudinal timbers of the bridge were severely decayed and overdue for replacement.

[8] https://www.railwaysarchive.co.uk/docsummary.php?docID=179.

Derailment near Liverpool Central underground station, 26 October 2005 (RAIB Report 14/2006)

151 The last bogie of a three-car passenger train derailed due to the widening of the track gauge during the passage of the train because the track was in poor condition. Track maintenance was not sufficient to prevent the condition of the track deteriorating over time. A computer simulation study, undertaken as part of the RAIB investigation, demonstrated the influence that the leading wheelsets had on the gauge presented to the following wheelsets. It showed that, on track having poor rail-sleeper lateral restraint, preceding wheelsets progressively widen the gauge. It also showed how increased flexibility led to increased spreading force and hence to progressive rail fixing damage which resulted in more spread.

Derailment at Angerstein Junction, 2 April 2014 (RAIB Report 11/2015)

152 Two wagons of a nominally empty freight train derailed on the approach to Angerstein Junction, near Charlton in south-east London. The wagons derailed because the leading right-hand wheel on one of them was carrying insufficient load to prevent the wheel climbing up the outer rail on a curved section of track. The insufficient load was due to a combination of a track defect, an unevenly distributed residual payload in the wagon, and an uneven distribution of load associated with a twisted bogie.

Derailment at Washwood Heath West Junction, Birmingam, 23 March 2015 (RAIB Report 01/2016)

153 One bogie of a wagon in a container train derailed on a set of points as it crossed between lines at Washwood Heath West Junction, in Birmingham. The bogie ran derailed for 121 metres before rerailing itself as it ran through another set of points. The track contained a twist fault of a magnitude which Network Rail's track maintenance standard specified should be rectified within 36 hours. Network Rail was not aware of the existence of this fault at the time.

154 Wagons should be capable of negotiating a track twist of a magnitude which the track standard allows to remain in a line open to traffic. When examined after the derailment, the liner on the centre pivot of the bogie was found to be worn beyond its maintenance limit. The centre pivot liner is made from a plastic material and is provided to allow relative movement between the body centre pivot and the bogie. The worn liner had restricted the freedom of the bogie to rotate, increasing its rotational stiffness. Furthermore, it resulted in reduced side bearer clearances, increasing wheel unloading in track twist conditions. Both the increased rotational stiffness and the increased wheel unloading reduced the wagon's resistance to derailment, causing it to derail when it encountered the track twist on the curved track. The worn centre pivot liner had not been identified during maintenance of the wagon as the maintenance instructions were unclear about when it should be inspected. A check on other wagons in the same fleet revealed that a number of other wagons of the same type had experienced a similar degree of centre pivot liner wear.

Freight train derailment at Lewisham, south-east London, 24 January 2017 (RAIB Report 04/2018)

155 Two wagons of a freight train derailed on newly laid track at Courthill Loop South Junction in Lewisham. The first of the wagons ran derailed, damaging the track, then overturned spilling its payload of sand. The RAIB investigation found that the derailment occurred because this wagon, which was probably carrying an uneven payload, encountered a significant track twist on tightly curved track. This resulted in there being insufficient wheel load to prevent its flange climbing over the railhead.

Failure of a longitudinal timber at bridge 2013, Haringey, August 2017

156 Part of a longitudinal timber from bridge 2013 (St Ann's Road) in Haringey, north London, fell onto the pavement of the street below on another part of the Barking to Gospel Oak route. On this bridge, the longitudinal timbers span between cross-girders but without a metal deck, so the underside of the timbers is visible from beneath the bridge. A member of the public reported the incident to the police. There were no injuries.

157 The longitudinal timbers on this bridge had already been identified as being in need of renewal, but as this was a relatively long bridge, the work was repeatedly deferred due to shortcomings with the arrangements for planning and funding the work. RAIB undertook a preliminary examination, but as the incident did not appear to be directly associated with the movement of a train, it did not undertake a full investigation. However, RAIB highlighted its concerns in a letter to Network Rail and the Office of Rail and Road (ORR) (Appendix C).

158 A Network Rail internal investigation found that the affected softwood timber had rotted internally to the heartwood, which crushed under load resulting in the section of wood detaching. The investigation also found that the route asset manager was not informed that the timber required renewal and that detailed knowledge of work needing to be done was lost due to the departure of staff.

159 ORR carried out an intervention and in November 2018, issued a Special Track Inspections Intervention Report to Network Rail which addressed the management of longitudinal timbers on Anglia route, including factors relating to the incident at bridge 2013. The review found that the route conducted no formal analysis of inspection information to see trends. The report recommended that the route should define in more detail exactly when and where drill samples should be taken and when a hammer should be used for sounding.

Summary of conclusions

Immediate cause

160 The track was unable to maintain the correct gauge as train 6Z54 passed over it (paragraph 43).

Causal factors

161 The causal factors were:

a. the rail restraint was inadequate leading to a persistent problem with wide gauge (paragraph 49, see action already taken (paragraph 171) hence no recommendation, **Learning point 1**)

b. track recording vehicles identified a wide gauge fault but output derived from this data did not result in track maintenance staff repairing faults at the correct location (paragraph 74, **Recommendation 1**)

c. Network Rail was not aware of the severity of the longitudinal timber degradation and so took no action to deal with this (paragraph 95, see action already taken (paragraphs 171 to 173) hence no recommendation, **Learning point 2**)

d. the condition of the trailing bogie on wagon 3415 imposed unusually high lateral loading on the track (paragraph 111) due to a combination of the following:

    i. a defect on wagon 3415 (paragraph 113, **Recommendation 2**)

    ii. uneven payload (paragraph 124, **Learning point 3**).

Underlying factors

162 The underlying factors were:

a. Network Rail's inspection and maintenance processes were insufficiently rigorous to identify timber deterioration before an unsafe situation developed (paragraph 129, action already taken (paragraph 172) hence no recommendation)

b. VTG's processes did not recognise an underlying problem with the wagon or bogie despite the unusual distribution and rate of flange wear on the wheels on some of its wheelsets (paragraph 139, **Recommendation 2**).

Observation

163 Three wagons on train 6Z54 exceeded the maximum permitted weight (paragraph 144, **Learning point 3**).

Previous RAIB recommendations relevant to this investigation

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

Freight train derailment at Angerstein Junction, 2 April 2014 (RAIB report 11/2015), published August 2015

165 Recommendation 5 of the RAIB report into the derailment at Angerstein Junction is relevant to the Wanstead Park derailment because it relates to the detection of incorrectly loaded wagons. The intention of this recommendation was to encourage use of available monitoring data from wheel impact load detection systems, such as Gotcha, to inform rolling stock maintenance.

Network Rail should review the potential to use wheel impact load detection system data to provide information about possible defects, such as uneven wheel loading or uneven load distribution, relating to specific wagons. The review should include cosideration of how this information could be used to improve control of overall derailment risk (such as identifying the need for entities in charge of maintenance to check the condition of suspect wagons and take appropriate remedial action). Network Rail should seek inputs from relevant entities in charge of maintenance as part of the review. If justified by the review, Network Rail should implement track side and reporting processes needed for collecting and disseminating this information.

166 Recommendation 6 is also relevant:

RSSB, in consultation with industry, should review the risks associated with the uneven loading of wagons, with particular reference to partial loads, and propose any necessary mitigation, so that the extent of permitted load imbalance is effectively controlled.

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

Network Rail - track recording vehicle data

167 Network Rail has informed RAIB that the Network Rail Technical Authority has been investigating how track geometry gauge fault reporting can be improved to identify all discrete gauge faults, and to aid track engineers with understanding the distance they need to inspect when visiting a wide gauge site. It is working with its suppliers to investigate alternatives to the hysteresis calculation.

168 Network Rail has stated that it has identified the main reason for differences in the positional accuracy reported by the various track recording vehicles and is working with its supplier to introduce an upgrade for its track recording vehicle fleet to deal with this issue.

VTG – wagon maintenance

169 VTG has informed RAIB that it is working on a data-driven maintenance programme for its wagons. This will involve input from trackside wheel weighing equipment, GPS tracking of wagons, and vehicle mileage.

DB Cargo - control of train loading operations

170 DB Cargo has informed RAIB that it has amended its procedures for loading trains at Barking to ensure wagons are not released from the facility with individual axle loads exceeding 25.4 tonnes.

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

171 Following several incidents on Anglia route, including the failure of part of a timber at bridge 2013 in August 2017 (paragraph 156), Network Rail commenced a detailed review of how it manages its longitudinal timber systems. Actions taken on Anglia route as a result of this review have included:

a. creating a new role of senior asset engineer (track structures) to centralise responsibility for managing the process of inspecting and renewing longitudinal timber systems and to provide support for team leaders based at depots and responsible for longitudinal timbers

b. instructing TMEs to provide reports to the senior asset engineer (track structures) for all longitudinal timber structures requiring renewal within three years so that the asset engineer can check that the correct priority has been assigned

c. introducing a four-weekly meeting between the senior asset engineer (track structures), track renewals engineer and structures engineer to co-ordinate the work of the delivery teams.

172 In March 2020, Network Rail published issue 7 of standard NR/L2/TRK/3038 ‘Longitudinal Bearer Systems – Inspection, Maintenance and Design’. Issuing the significantly updated standard was already at an advanced stage when the accident occurred at bridge 456. The new version of the standard provides additional guidance for staff and introduces a new TEF 3279 Long Bearer Management Plan for each structure. This requires provision of photographs and sketches and is intended to exist as a live document, being updated when work is completed. After each detailed examination TEF3279 shall be reviewed and, if necessary, revised by the TME and the section manager (track). The Long Bearer Management Plan requires a structure specific risk assessment of the frequency at which any walkways should be lifted.

Standard 3038 (issue 7) also includes:

a. advice on factors to consider when establishing the year of expiry of the bearers (module 2, clause 5.7)

b. the requirement for examinations to include drainage and ventilation arrangements (module 2, clause 5.4)

c. the requirement that non-destructive and intrusive testing shall include the use of an approved microdrill [a very small diameter drill to avoid drilling large holes in timbers]

d. a reminder that the internal condition of the timber can be poor even if the surface is good (module 2, Clause 5.5)

e. a requirement that staff responsible for inspecting longitudinal timber systems should be provided with information on recently recorded track faults in advance of their inspection.

173 Network Rail has notified RAIB that it is updating its training syllabus to accompany the roll-out of issue 7 of standard NR/L2/TRK/3038. The full course will be delivered to staff learning to undertake longitudinal timber inspections. Staff who already hold the competency and are currently responsible for undertaking these inspections will receive training on new and updated elements. The specification for the new course includes measures to address the following gaps identified by RAIB during this investigation:

a. how to grade the timber as Good / Fair / Poor ratings and link this to estimated remaining life, taking account of site conditions

b. how to complete the TEF3014 form (including the importance of highlighting key findings in the summary of the inspection report so that the need for any action is identified).

Recommendations and learning points

Recommendations

174 The following recommendations are made:[9]

1 *The intent of this recommendation is to reduce the risk that track maintenance staff miss defects identified by track recording vehicles; it is likely that work already started by Network Rail will assist implementation of this recommendation.*

Network Rail should take measures to improve the clarity of information provided from Track Recording Vehicle systems, and the procedures adopted by those investigating defects, to assist track maintenance staff to correctly locate all recorded defects. The improvements shall include consideration of:

- ways of identifying discrete defects when these occur within one area of relatively poor track quality where multiple defects are currently reported as a single defect at one location due to the 'hysteresis threshold' feature of the track recording vehicle system
- the extent to which staff should look for defects beyond a nominal defect position due to inaccuracies in locations determined using global positioning system (GPS) equipment (paragraph 161).

2 *The intent of this recommendation is to reduce the risk of defective rail vehicles entering service; it is likely that work already started by VTG will assist implementation of this recommendation.*

VTG should review and improve monitoring of maintenance activities on individual rail wagons to detect repetitive maintenance requirements which may indicate an underlying fault which is not being addressed (paragraph 162b).

This recommendation may apply to other Entities in Charge of Maintenance.

[9] 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

175 RAIB has identified the following important learning points:[10]

1 Staff involved with management of longitudinal timber systems constructed from softwood are reminded that these may lose significant strength before decay or degradation becomes clearly visible on the surface (paragraph 161).

2 The importance of providing longitudinal timbers with an environment which is free from standing water, well ventilated and fully visible to staff carrying out inspections (paragraph 161).

3 Freight terminal operators and freight operating companies are reminded of the importance of avoiding over-loaded or unevenly loaded wagons as addressed by the National Freight Safety Group code of practice 'Loading bulk wagons' NFSG-COP-004. This should include:

- allowing for any residual payloads from previous journeys
- adopting loading techniques which reduce any tendency to fill wagons unevenly
- using wagon weighing data and Gotcha monitoring system data to identify uneven loading (paragraphs 161 and 163).

[10] '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

EMGTPA	Equivalent million gross tonnes per annum
GPS	Global positioning system
ORR	Office of Rail and Road
POD	Point of derailment
RSSB	Rail Safety and Standards Board
TME	Track maintenance engineer
TOPS	Total Operations Processing System

Appendix B – Sources of evidence

RAIB used the following sources of evidence in this investigation:

- information provided by witnesses
- Network Rail standards
- longitudinal timber and track inspection records
- track recording vehicle data
- examination of the accident site including measurement and testing of the track
- physical examination of longitudinal timbers
- wagon maintenance records
- examination of wagons 3415 and 3114
- wagon loading (WeighWell) data
- on-train monitoring recorder (OTMR) data from locomotive number 66154.

Appendix C – Copy of letter from RAIB to Network Rail dated 15 September 2017 in response to a longitudinal timber failure on bridge 2013 in August 2017.

[redacted]
Corporate Investigation and Assurance Manager
Network Rail
The Quadrant: MK
Elder Gate
Milton Keynes
MK9 1EN

Dear [redacted]

Partial loss of track support, bridge 2013, St Ann's Road, Haringey, 26 August 2017

I am writing to advise you of the outcome of the RAIB's preliminary examination into an incident that occurred at St Ann's Road, Haringey overnight on 25/26 August 2017. A large piece of timber was found under the bridge by a member of the public (figure 1), and was reported to Network Rail by the Metropolitan Police. The wood was part of an unsupported longitudinal timber (ie there was no supporting deck plate) carrying the 6 foot rail of the up line which had rotted. Network Rail staff initially imposed a 5 mph emergency speed restriction, but the line was later blocked when track maintenance staff determined that the timber had to be renewed. The remaining section of the timber was found to have rotted through from the top and it disintegrated as it was being removed from the bridge on 28 August (figure 2). Sections examined by the RAIB on 30 August were found to be spongy and wet.

Figure 1: Timber section found on pavement

Figure 2: Condition of longitudinal timber on removal

Bridge 2013 carries the Gospel Oak to Barking line (TAH1 and TAH2) over the junctions of St Ann's Road and Seven Sisters Road in Haringey, north London. The line is currently being electrified, which will allow an improved passenger service and an increase in the number of freight paths available to access the London Gateway container port on the Thames east of Tilbury. Project works have included renewal of four bridges and modernisation of six others, but the route has still has numerous underbridges with longitudinal timber track support systems.

The current longitudinal timbers on bridge 2013 were installed in about 1986 with a 20 year service life. By 2012, their condition had deteriorated to the extent that the Barking Track Maintenance Engineer proposed that the timbers be renewed.

Longitudinal timber systems, because of their vulnerability, are subject to annual inspections in accordance with Network Rail standard NR/L2/TRK/3038. The last three TEF3014 long timber examination reports for this bridge have marked the timbers as ‘red’, meaning replacement required in 1-12 months. The length of the bridge meant that this activity exceeded the capability of the local delivery unit and required funding from the CAPEX budget. The RAIB understands that, prior to the incident, this renewal work was planned for 2019.

Prior to the line reopening after an eight month electrification blockade in February 2017, the newly-appointed Infrastructure Maintenance engineer (IME) sent an email to the RAM [Track] proposing that advantage be taken of the blockade to gain access and renew timbers. The RAM [Track] did not take the proposal forward, apparently due to budget constraints. The line reopened with tie bars fitted and a 20 mph emergency speed restriction. The poor condition of the longitudinal timbers is illustrated in a photograph dated January 2017 (figure 3) which shows the disintegration of the top surface.

Figure 3: photograph dated January 2017

Figure 4: damaged timber from below. Daylight is visible.

A structures visual examination report dated March 2017 identified that urgent attention was required to replace the severely decayed wheel-timbers. This concern was raised by the examiner even though longitudinal timbers are not deemed a structures asset. The IME forwarded a copy of this report to the RAM [Track] to reinforce his request that action be taken. The most recent supervisor’s inspection in August 2017 also categorised the affected timber as ‘poor’.

It is apparent that numerous warnings were raised about the deterioration of the longitudinal timbers on this bridge. In view of the similarities with the 1997 Bexley derailment which was caused by significant deterioration to the track support and fastenings, I would like to draw your attention to the following aspects of this event:

1. The RAM [Track] did not approve work to renew the longitudinal timbers. The RAIB has not sought to establish why, but observes that as the longitudinal timbers on bridge 2013 were un-supported (ie there was no deck plate beneath the timbers - figure 4), so were required to have the strength necessary to carry and transfer rail traffic loading to the supporting structure.
2. A review, required by standard NR/L2/TRK/3038 when the tonnage of traffic using a longitudinal timber bridge was expected to increase significantly, either did not occur, or did not identify that work was urgently required.

3. It would appear that the sponsors of the electrification project either did not identify, or did not promote/support work which essential for the project's own success. This is surprising, as the scope of the project included bridgeworks elsewhere on the line.

The RAIB has decided to take no further action in respect of this incident. However, given the apparent safety management issues it raises, we advise Network Rail to take the above points into account when concluding their own investigation and developing recommendations to prevent a reoccurrence. I am copying this letter to the Office of Rail and Road for their information.

Yours sincerely,

[redacted]
Deputy Chief Inspector of Rail Accidents

Copy to:

[redacted]
Office of Rail and Road,
1 Kemble Street,
London
WC2B 4AN

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

Any enquiries about this publication should be sent to:

RAIB
The Wharf
Stores Road
Derby UK
DE21 4BA

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