Rail Accident Investigation Branch

Rail Accident Report

Freight train derailment at Reading West Junction
28 January 2012

Report 02/2013
January 2013

This investigation was carried out in accordance with:

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

Any enquiries about this publication should be sent to:

RAIB	Email: enquiries@raib.gov.uk
The Wharf	Telephone: 01332 253300
Stores Road	Fax: 01332 253301
Derby UK	Website: www.raib.gov.uk
DE21 4BA	

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

Freight train derailment at Reading West Junction, 28 January 2012

Contents

This page is left intentionally blank

Summary

At 13:42 hrs on 28 January 2012 a wagon on a container train derailed, and then re-railed, when crossing a section of track connecting two lines (a crossover) at Reading West Junction. No-one was injured. However, the condition of the train was such that the derailment could have taken place elsewhere, in which case the consequences might have been more severe.

The train was formed of 25 container-carrying flat wagons. The wagon that derailed was the 24th from the front. It was carrying a single freight container on the trailing end, which was packed with 13 pallets of automotive components, each weighing approximately 1300 kg. On opening the container, the RAIB found that all the pallets were unsecured and had moved to the side, resulting in uneven loading of the wagon. A survey of the track revealed a geometry defect (a twist fault) close to the point of derailment.

The cause of the derailment was that there was insufficient load on the front right-hand wheel of the wagon to prevent its flange climbing over the railhead. This was the combined result of the uneven loading on the wagon, specifically the lateral offset of the payload in the container, and the effect of the twist fault on the crossover.

The RAIB concluded that the pallets had moved during the road journey to the freight terminal where the container was loaded onto the train. Schaeffler Automotive, the company that packed the container, had no processes at the time to ensure that the pallets would not move. The checks and handling methods used by Freightliner, the operator of the terminal, did not detect the offset load.

Although the size of the twist fault did not require the line to be blocked to traffic, Network Rail's processes for track inspection and maintenance had not identified that it existed.

The RAIB has made five recommendations, one directed to the Health and Safety Executive, two to Freightliner and two to Network Rail. They are concerned with:

- making relevant parties aware of the need to pack freight containers in accordance with published guidance, and gaining assurance that this is being done;
- the detection of at-risk freight containers and wagons before they enter traffic;
- the detection of track geometry defects after mechanised maintenance; and
- minimising the formation of track geometry defects during mechanised maintenance.

Introduction

Preface

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

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

Key definitions

3 All dimensions in this report are given in metric units, except train speed, railway locations and freight container dimensions, which are given in imperial units in accordance with normal practice. Where appropriate the equivalent metric value is also given.

4 All mileages in this report are measured from a zero datum at London Paddington station. The directions left and right are relative to the direction of travel of the train.

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

The incident

Summary of the incident

6 At 13:42 hrs on 28 January 2012 a wagon within freight train 4O02[1] derailed, and then re-railed, as it was passing over a *crossover* at Reading West Junction, near Reading station (figure 1). Train 4O02 was the 11:11 hrs container service from Lawley Street (Birmingham) to Southampton Maritime.

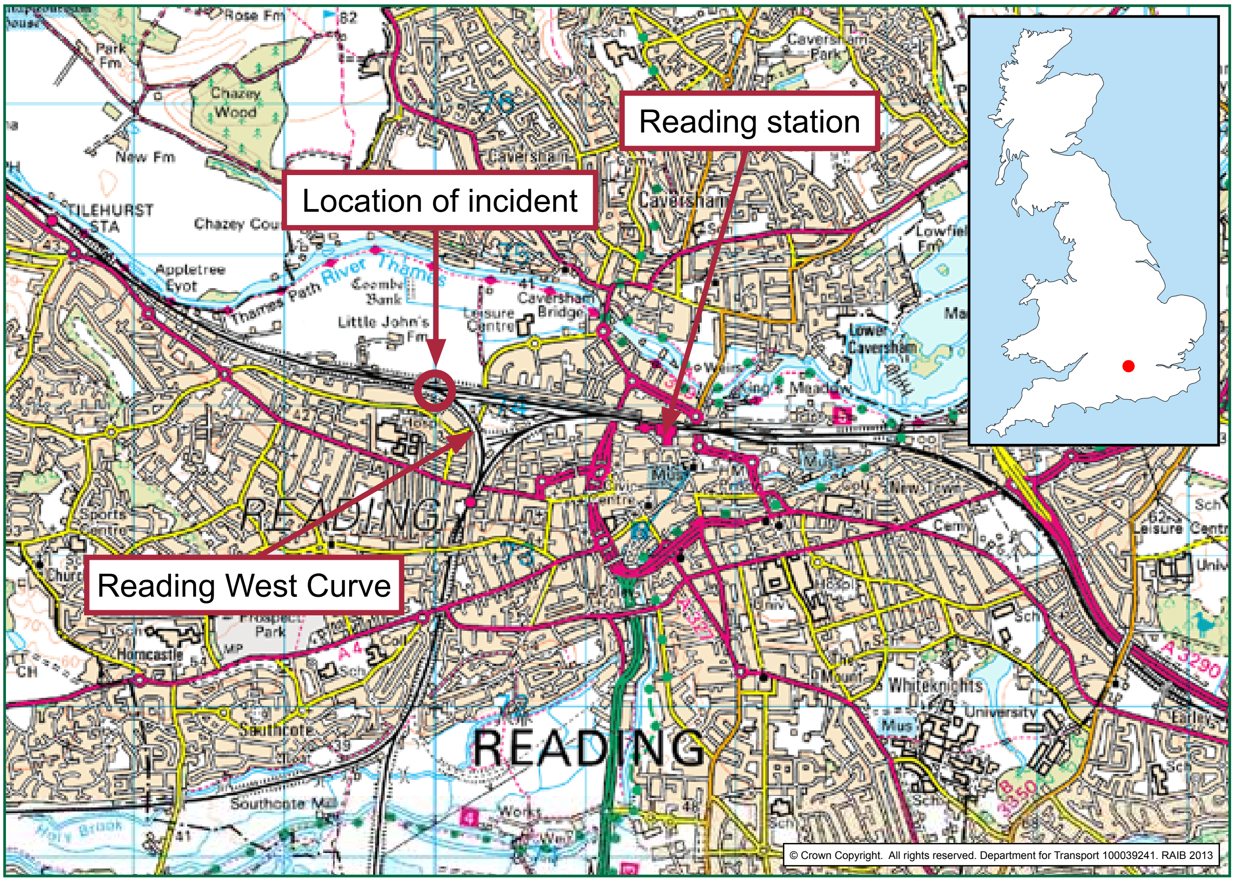


Figure 1: Extract from Ordnance Survey map showing location of incident

7 Train 4O02 had been routed from the *up* goods reception line to the up west curve line (figure 2). Both wheelsets on the leading bogie of the 24th wagon derailed to the right as they traversed the crossover between the up relief and up main lines (referred to in the report as ‘crossover 3717’[2]). They re-railed again as they *trailed* through the points at the crossover exit (716a points).

8 There was minor damage to the track and the derailed wagon, and significant disruption to rail services in the area. No-one was injured. The design of the track and signalling arrangements at Reading West Junction prevented the possibility of collision with the majority of other trains at that location, including those going into and out of Reading station. However, train 4O02 was at risk of derailing elsewhere on its journey, including locations where it could have infringed the path of passenger trains.

[1] The derailed train is referred to in the report by its reporting number, a four-character alphanumeric code that is used to identify it for operational purposes.

[2] Based on the identification number Network Rail had given this section of track.

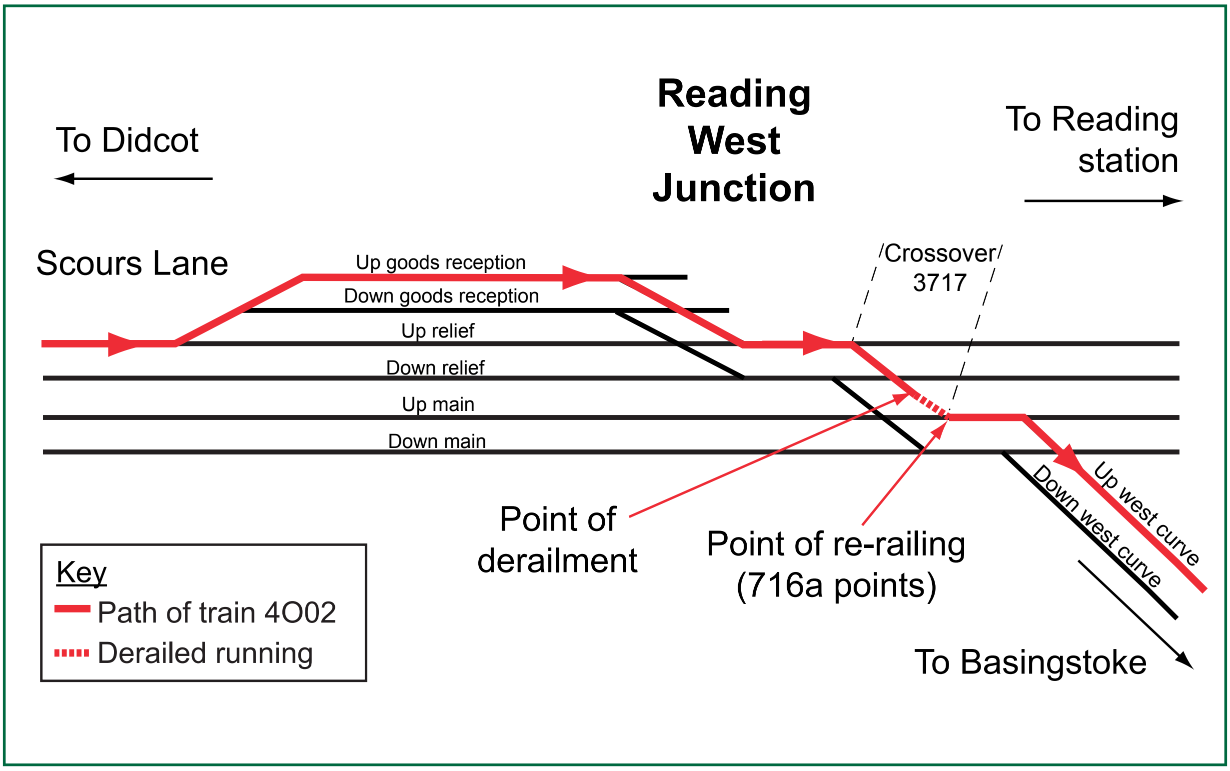


Figure 2: Track layout at Reading West Junction showing the path of train 4O02

Context

Location

9 Reading West Junction is on the *Great Western Main Line* at 35 miles 78 chains, around 1.5 km west of Reading station (figure 1). Here the railway comprises six tracks: the up and *down* main lines, the up and down relief lines and the up and down goods reception lines (figure 2). Reading West Curve, which branches off at the junction, enables southbound trains, from the Midlands and the West, to bypass the station.

10 The following permanent speed restrictions apply:

- Main lines, 125 mph (201 km/h).
- Relief lines, 75 mph (121 km/h) for passenger trains[3] and 60 mph (97 km/h) for other trains.
- Goods reception lines, a mixture of 25 mph (40 km/h) and 40 mph (64 km/h).
- Crossovers (including crossover 3717), 25 mph (40 km/h).

11 The signalling is controlled by the *Thames Valley Signalling Centre* at Didcot. It played no part in the incident.

12 A programme of infrastructure upgrade work is currently underway in the area of Reading station. This includes construction of a new *flyover* so that trains will be able to cross the mainline onto Reading West Curve without the need to traverse the type of track layout where the derailment occurred. Crossover 3717 will be removed.

[3] Also for parcels and postal trains.

Organisations involved

13 Schaeffler Automotive (Schaeffler), a manufacturer and distributor of automotive components, packed the single freight container that was being carried on the wagon that derailed. It had made arrangements with MacAndrews, *a freight forwarder*, for the container to be exported to China.

14 MacAndrews arranged the road transport to collect the container from Schaeffler's warehouse in Hereford and transport it to the *inter-modal freight terminal* at Lawley Street for transfer to train 4O02.

15 Freightliner, a railway *freight operating company*, maintained and operated train 4O02. It also operates the terminal at Lawley Street, where the train was loaded and prepared prior to departure for Southampton Maritime.

16 Network Rail owns and maintains the railway infrastructure where the derailment occurred.

17 Schaeffler, MacAndrews, Freightliner and Network Rail freely co-operated with the investigation.

Train involved

18 Train 4O02 comprised a class 66 diesel electric locomotive and 25 container-carrying flat wagons. The derailed wagon was one of a pair of semi-permanently coupled FEA wagons: FEA 640165 (the 23rd wagon) and FEA 640166 (the wagon that derailed, subsequently referred to in the report as 'wagon 24'). A single freight container, OOLU 8740103 (40 feet long by 9 feet 6 inches high), was loaded on the leading end of the 23rd wagon. The single container on wagon 24 (paragraph 13), WFHU 4147370 (40 feet long by 8 feet 6 inches high), was loaded on the trailing end. Figure 3 shows the train configuration and the position of the containers.

Track involved

19 In the vicinity of the derailment, the track comprises *flat-bottom* rail fastened, with *pandrol clips*, to metal *baseplates* on timber sleepers. It is supported on stone ballast.

20 A team based at Network Rail's depot in Reading inspects and maintains the track at Reading West Junction. The last maintenance of the track was when Network Rail arranged and supervised mechanised maintenance work to improve the track geometry in the area between 24 and 26 December 2011.

Staff involved

21 The Schaeffler warehouse assistant who packed container WFHU 4147370 had worked in its warehouse in Hereford for 23 years.

22 A Freightliner shift supervisor undertook the *pre-departure check* (paragraph 80) of train 4O02 at the Lawley Street terminal. He had worked for Freightliner (and its predecessor organisations) for over 20 years, the last six years of which had been in terminal operations. Freightliner issued him a certificate of competence to show that he had been assessed as competent in the relevant company and railway industry standards and procedures relating to *shunting* and *train preparation* duties.

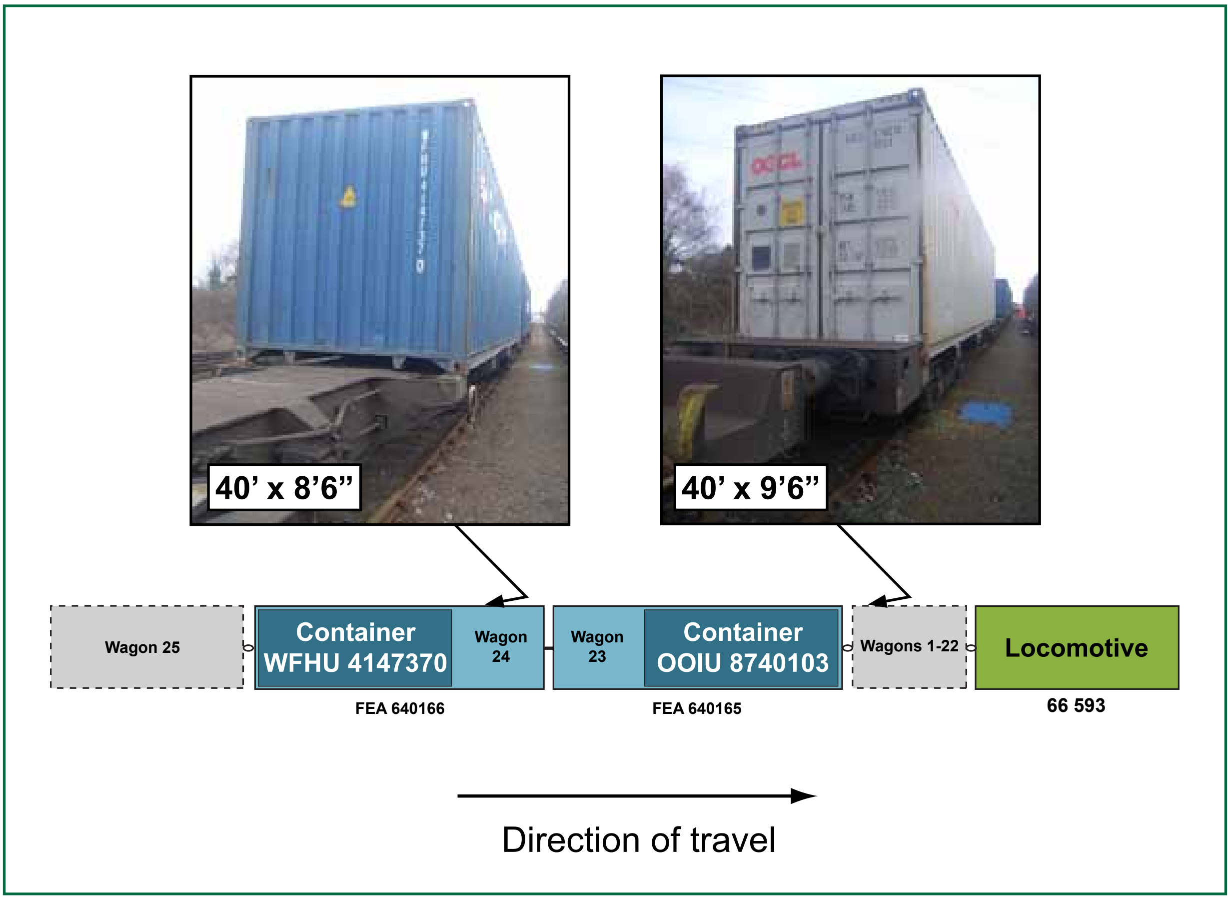


Figure 3: Configuration of train 4O02

23 The Network Rail *track quality supervisor* (TQS) who supervised the mechanised maintenance work on crossover 3717 in December 2011 (paragraph 20) had 21 years track maintenance experience with the company and its predecessor organisations. Network Rail had assessed his competence and issued him with an 'authority to work' in this role.

External circumstances

24 The weather at the time of the derailment was reported[4] as 'mostly cloudy' with a north wind of speed 16.7 km/h and no gusting. The temperature was 5ºC and the relative humidity was 81%. The recorded daily rainfall for 28 January 2012 was 0.2 mm. The RAIB found no evidence that the weather played any part in the incident.

Events preceding the incident

25 At 08:25 hrs on Friday 27 January 2012, a road haulier, subcontracted to MacAndrews, delivered freight container WFHU 4147370 to Schaeffler's warehouse in Hereford. After opening the rear container doors, the haulier's driver reversed onto the loading dock for the empty container to be packed.

[4] Based on records for Farnborough Airport, 25 km southwest of Reading.

26 Schaeffler's warehouse assistant then used a forklift truck to pack the container with 13 wooden pallets of pre-packaged automotive components; each pallet was around 1200 mm by 800 mm and weighed approximately 1300 kg. There were not enough pallets to cover the floor of the container in a tightly packed arrangement. As a result the warehouse assistant placed the pallets in a line down the centre of container so that the container's end-wall and doors limited any longitudinal movement due to braking and acceleration during road transit. Figure 4 shows how the pallets were packed.

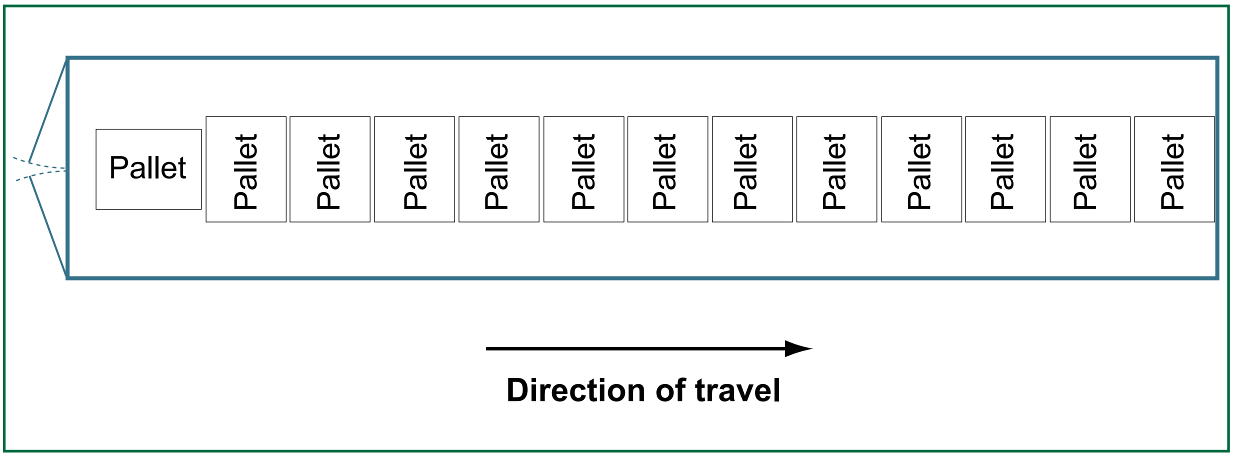


Figure 4: Container WFHU 4147370 as packed at Schaeffler's warehouse

27 With the container packed, the lorry driver would have pulled off the loading dock and closed and sealed the container doors. At this point, the driver may have looked inside the container, but there is no evidence that he raised any concerns. The lorry departed at around 09:45 hrs. It is likely that no-one other than the lorry driver and the warehouse assistant saw the packed cargo before the container left.

28 The container was delivered to Freightliner's Lawley Street terminal in Birmingham at 23:24 hrs, where office staff booked it in. Records show that it was loaded on the trailing end of wagon 24 of train 4O02 by 01:21 hrs on 28 January.

29 The shift supervisor that undertook the pre-departure check of train 4O02 (paragraph 22) started his shift at 05:00 hrs. He recalled nothing particular about the train or its loading. He signed both the *train document* (for the driver of the train to take) and the checklist that declared his checks were in accordance with Freightliner's operating procedure.

30 Train 4O02 departed the Lawley Street terminal at 11:00 hrs, 11 minutes early. The shift supervisor, the shunter[5] and the technician[6] watched from the trackside as it left.

[5] The terminal staff member who directed the coupling together of the train.

[6] The terminal staff member who carried out an engineering examination of the loaded train.

Events during the incident

31 On approaching Reading, the train was signalled into the up goods reception line at Scours Lane (37 miles 60 chains). Shortly afterwards, at 13:42 hrs, it was routed out and over the series of crossovers at Reading West Junction (36 miles 76 chains) that led it onto the up west curve (figure 2).

32 At 13:45 hrs Network Rail reported that a signalling *track circuit*[7] had failed at the junction shortly after train 4O02 had passed. Network Rail's fault team found damaged track circuit cables and track components (figure 5), and reported that they suspected that train 4O02 had derailed and then re-railed. The point of derailment was on a plain line section of crossover 3717, mid-way between the *diamond crossing* on the down relief and 716a points on the up main (figures 2 and 6).

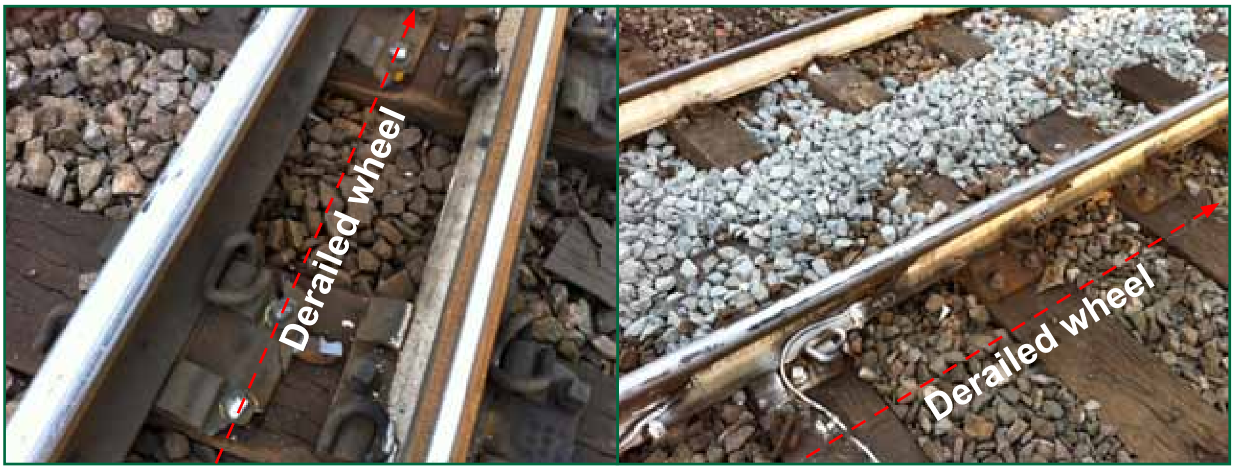


Figure 5: Damage to track and track circuit cables (photographs courtesy of Network Rail)

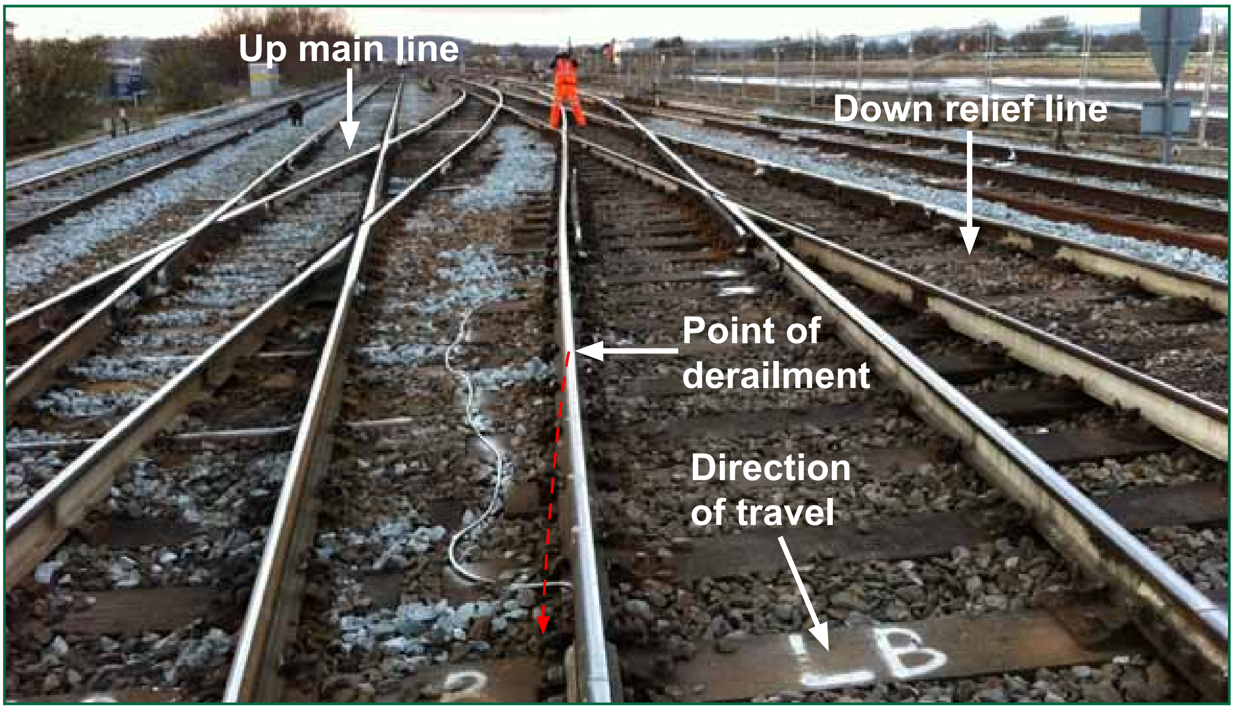


Figure 6: Location of the derailment on crossover 3717 (photograph courtesy of Network Rail)

[7] The failure of the track circuit caused signals to show red, thereby preventing other train movements.

33 At 14:22 hrs Network Rail instructed the train driver to stop at Worting Junction, around 4 km west of Basingstoke station, so he could examine the train. The driver identified marks on wagon 24 consistent with the wheels having run derailed. With the examination complete, the driver was given permission to drive the train to Southampton at reduced speed.

The investigation

Sources of evidence

34 The following sources of evidence were used:

- examination of the derailed train, the container on wagon 24 and track in the vicinity of the derailment;
- the train's *on-train data recorder* (OTDR) data and closed circuit television (CCTV) recordings taken from stations that the train passed prior to the derailment;
- railway industry control logs, and train and signalling operation records;
- information relating to the shipping and handling of the container;
- track inspection and maintenance records;
- witness statements;
- guidance and standards for the packing and handling of freight containers, such as those published by the *International Maritime Organization* (IMO) and the *International Organization for Standardization* (ISO); and
- information relating to Network Rail's standards and processes for the maintenance and inspection of track, and the training of TQSs.

Key facts and analysis

Background information

Examination of the derailed train

35 The RAIB examined the train after the derailment and identified evidence of heavy *primary suspension lift stop* contact and wheel damage (figure 7), which indicated that the leading bogie on wagon 24 had run derailed.

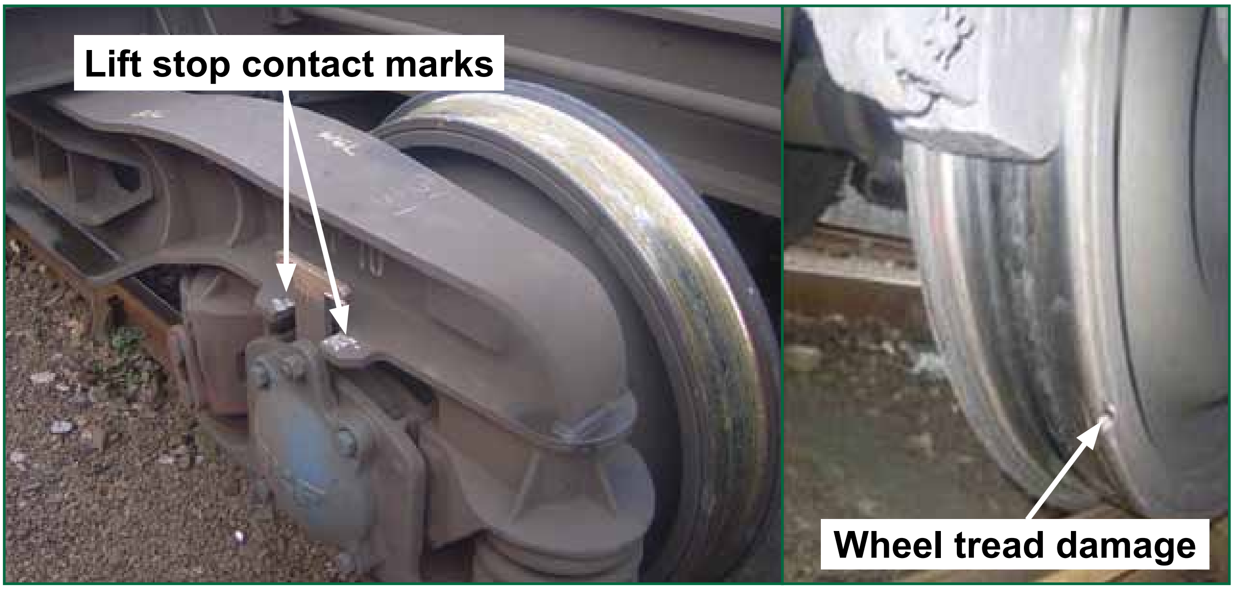


Figure 7: Evidence of primary suspension lift stop contact and wheel damage on leading bogie of wagon 24

36 The RAIB also observed that container WFHU 4147370, on the rear of wagon 24, was slightly tilted to the left (figure 8a). On opening the container, the RAIB found that the 13 pallets inside (paragraph 26) were to the left, the majority in contact with the container sidewall (figure 8b).

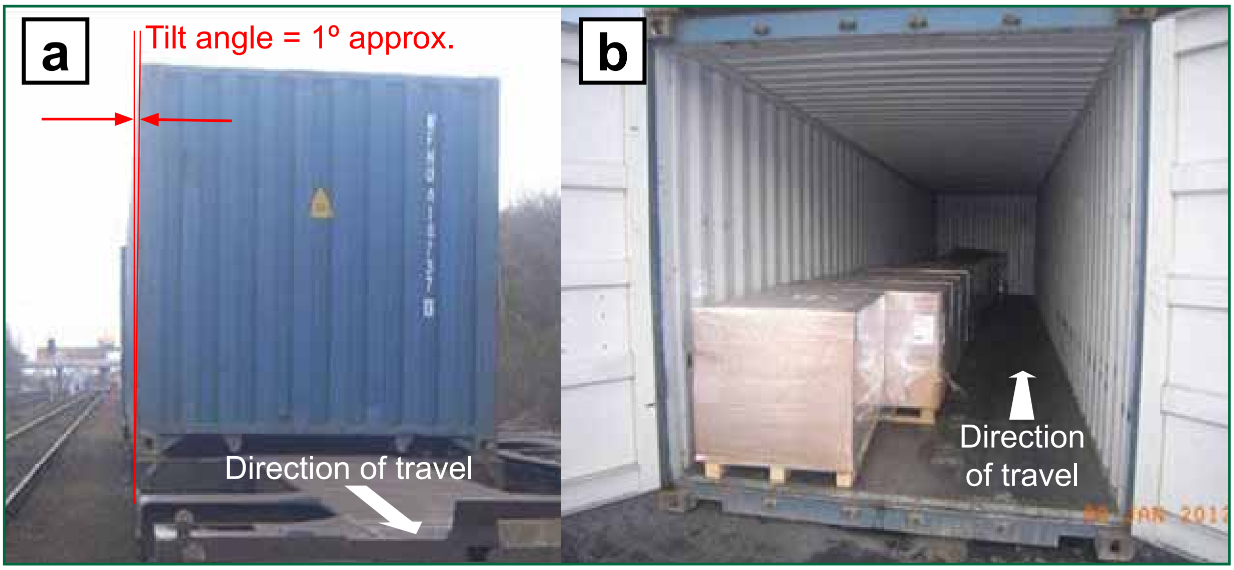


Figure 8: Container WFHU414737 showing the tilt and the location of its contents when examined at Southampton Maritime

Guidance and standards for packing freight containers[8]

Guidelines published by the IMO

37 The IMO publishes guidance for the packing of freight containers, vehicles and other *cargo transport units* (CTUs), which it has developed jointly with the *International Labour Organization* (ILO) and the *United Nations Economic Commission for Europe* (UNECE). The current edition, entitled 'IMO/ILO/UNECE guidelines for packing of cargo transport units' (IMO/ILO/UNECE guidelines), was published in 1997[9].

38 The above guidelines acknowledge that a person packing cargo into a CTU may be the last person to see inside it before it is opened at its final destination. Many people in the transport chain may be at risk from a poorly packed freight container, or other type of CTU, and are therefore reliant on those who do the initial packing.

39 The guidelines:

- Give background information concerning the forces that may arise during transit: whether by sea, road, rail or waterway.
- Give practical guidance on how to safely pack cargo, specifically emphasising the need to ensure that:
    - it is secure and cannot move within a CTU;
    - the centre of gravity is 'at or near the longitudinal centreline of the CTU'; and
    - for a container, the weight is evenly distributed on the floor, or, where this is not possible, close to its mid-length.
- Emphasise the need for training for those packing CTUs, and list the topics to be included in a training programme. These include the consequences of poorly packing and securing cargo, the forces acting on cargo during transit and the principles and methods for cargo packing and securing.

ISO standards

40 ISO publishes a standard defining the method for handling freight containers like WFHU 4147370: ISO 3874, 'Series 1 freight containers – Handling and securing', dated 1997. ISO 3874 covers various operational requirements including container lifting, *landing*, stacking and securing - on ships, and road and rail transport. It also refers to container packing, stating that the cargo shall be distributed so the centre of gravity is kept as 'central and as low as possible', and stowed and secured to prevent damage which may result from 'dynamic conditions encountered during handling and transportation'. It also makes reference to information in the document that was the forerunner to the IMO/ILO/UNECE guidelines[10].

---

[8] Appendix C gives publication details for the documents referred to in this section.

[9] The IMO, ILO and UNECE are currently meeting to update the guidelines.

[10] IMO/ILO guidelines for packing cargo in freight containers or vehicles, IMO, 1985.

Other guidance

41 There is a variety of other international, national and industry guidance that relates to the safe packing of containers, including:

- British Standard BS 5073, 'British Standard guide to stowage of goods in freight containers';
- 'European best practice guidelines on cargo securing for road transport', published by the European Commission;
- 'Code of practice – safety of loads on vehicles', published by the Department for Transport;
- 'Safe transport of containers by sea – industry guidance for shippers and container stuffers', published by the International Chamber of Shipping; and
- 'Working with containers – an FTA best practice guide', published by the Freight Transport Association.

42 The majority of these documents emphasise that cargo needs to be stowed securely, with the centre of gravity as central as possible. Most also refer to the guidance in the IMO/ILO/UNECE guidelines, or follow the principles it sets out.

Track twist

43 *Track twist* is the variation in *cant* over a given distance, where cant is a measure of the height of one rail above the other. The amount of track twist is usually defined as the rate of change of cant over this distance, and expressed as a value of 1 in x. Ideally, the cant is measured when the track is under load from a train and any change in cant, due to the compression of any gaps or voids under the track, has been accounted for.

44 Network Rail standards and processes for track inspection and maintenance call for the track twist to be measured over a base distance of 3 metres, and maintenance limits for track twist are based on this. For example, a track twist limit of 1 in 200 would represent a difference of 15 mm between two cant readings taken 3 metres apart.

Post-incident examination of the track

45 The point of derailment was identified as being at the seventh *timber bearer,* on crossover 3717, after the *crossing nose* of the diamond crossing on the down relief line. Network Rail surveyed the track in the vicinity using a *track gauge* and found a track twist that measured 1 in 188 over the standard 3 metre base. It started close to the point of derailment, and continued over the next two timber bearers in the direction of travel.

46 The timber bearers connect the crossover to the adjacent through running lines. The timber bearer connection changes just after the point of derailment. The bearers leading to the fourth timber bearer after the point of derailment connect to the down relief; beyond the fifth timber bearer they connect to the up main. Figure 9 shows the layout of the crossover in the vicinity of the derailment, the point of derailment, the values of the measured track twist and the arrangement of the timber bearers.

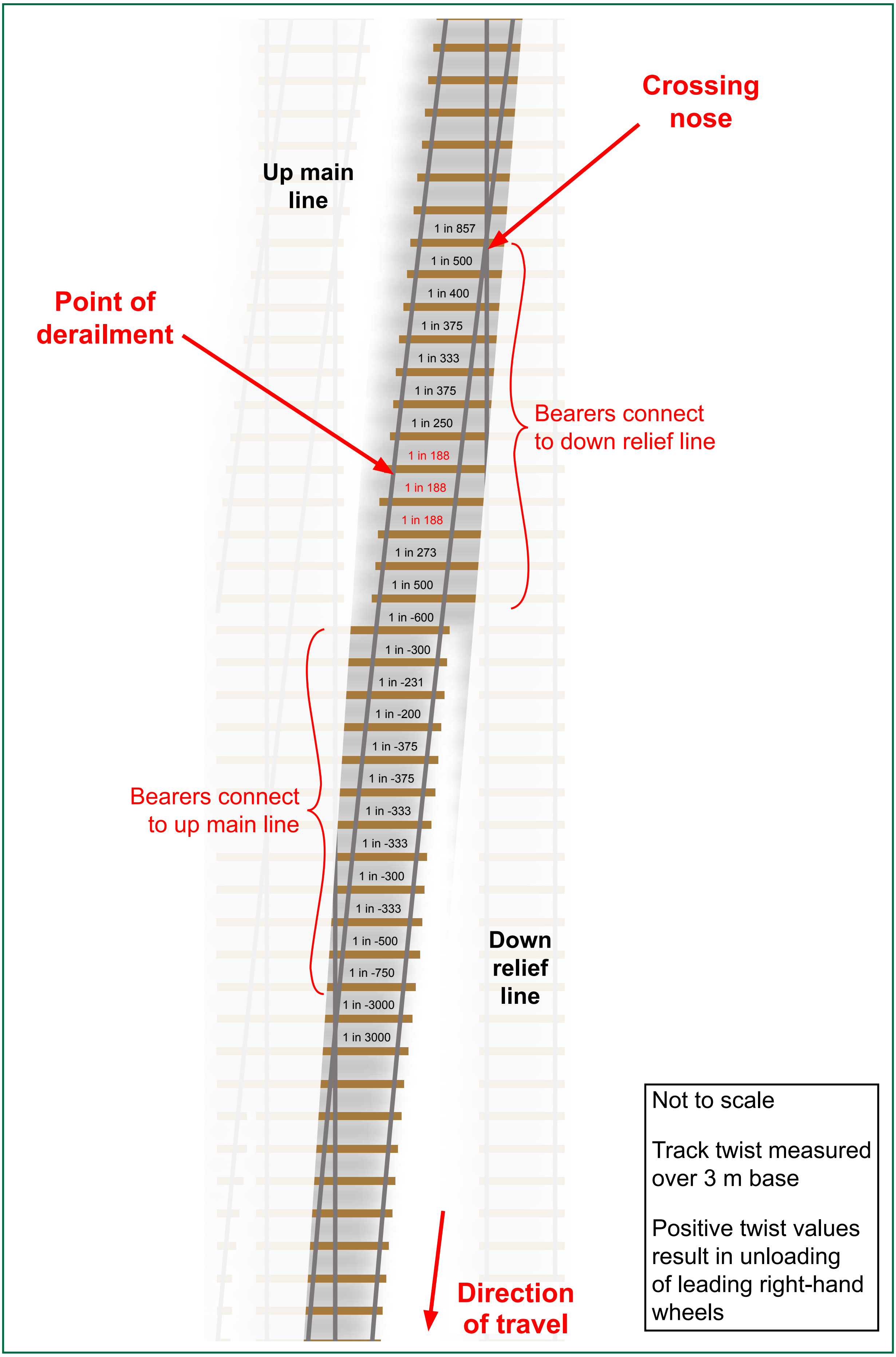


Figure 9: Track layout in the vicinity of crossover 3717 showing the measured twist values

47 The paths of two wheelsets derailing to the right, and then re-railing at 716a points on the crossover exit, were identified from witness marks on the track.

Inspection and maintenance of the track

Inspection

48 Network Rail requires routine visual inspection of its track in accordance with its standard NR/L2/TRK/001, 'Inspection and maintenance of permanent way'. The frequencies of inspection depend on the type of track (for instance, whether it is an area of *switches and crossings* (S&C), it is jointed or it is *continuously welded*) and its track category (which is determined from the line speed and the annual loading from trains that use it). The track at Reading West Junction was an area of S&C; crossover 3717 was classed as track category 4, and the main and relief lines were classed track category 1A. As a result, the following minimum visual inspection frequencies were required:

- a basic visual track inspection by *patroller*s every week;
- a *supervisor* visual track inspection every eight weeks for the main and relief lines, and every 13 weeks for the crossover; and
- a *track maintenance engineer* (TME) visual track inspection every two years.

The overall aim is to identify defects that could affect the safe and reliable operation of the railway. Although inspection staff are expected to identify and report on other concerns with the infrastructure, their focus is on the condition of the track. The items to be covered incorporate the track components (including the switches and crossings), the supporting ballast and the drainage. Staff are also expected to report on any track geometry defects, such as track twist.

49 Basic visual track inspections are used to identify if any immediate and short-term actions are needed. At Reading West Junction, the patrollers carry these out using a combination of four pre-planned inspection walks, each done every two weeks. Two of the walks require the patroller to inspect the track on crossover 3717. The inspection reports, for the 10 weeks prior to the derailment, showed that the overall frequency of inspections was compliant with Network Rail's requirement. None identify any concern with the track twist on the crossover.

50 Supervisor visual track inspections are used to decide how to respond to issues identified in the basic visual track inspection reports. The inspections also require that measurements of track twist are made 'at intervals along the track to suit the track condition'. The last such inspection of Reading West Junction was undertaken on 20 December 2011, less than six weeks before the derailment and therefore was compliant with Network Rail's requirement. The reports from this inspection listed previously identified issues concerning the *lifting and packing* of timber bearers on the main and relief lines in the vicinity of crossover 3717. The supervisor confirmed these, but found no additional relevant issues. The reports detail no measurement of, or concerns with, the track twist on the crossover.

51 The TME's visual track inspection is used to check the performance of those carrying out the basic visual and supervisor visual track inspections. The track at Reading West Junction was last inspected by the TME on 22 September 2010, within the required inspection interval of two years. The inspection report identified the need for *tamping* of the relief lines at the junction, and a hand-written note recorded that this work was done on 1 January 2011. The report details no measurement of, or concerns with, the track twist on the crossover.

52 The supervisor and the TME supplement their visual track inspections with *cab riding*. The last supervisor cab ride was on 24 January 2012 and identified ‘poor top’ on the up main line near crossover 3717, indicating a deterioration of the track vertical geometry; no issues were identified on the other main and relief lines. The last TME’s cab ride, for the up and down relief lines, was on 20 December 2011. It recorded nothing untoward at the junction. No cab riding is done over crossover 3717 itself.

53 In addition to visual inspections, Network Rail routinely makes continuous recordings of the track geometry on running lines in order to find track twists, and other discrete geometry faults[11]. In line with its general practice, Network Rail used a special *track measurement train* to record the geometry on the main and relief lines in the immediate vicinity of crossover 3717. However the crossover itself was on a register of sites where Network Rail had determined that no such recordings were required (paragraph 91). No track twists or vertical track geometry features, which exceeded the maintenance limits in NR/L2/TRK/001, were observed on the *recording traces* from the last track measurement train runs over the main and relief lines.

Maintenance

54 The last track maintenance at Reading West Junction was undertaken in December 2011 (paragraph 20) using a single *tamping machine*, which was designed for treating areas of S&C. The work was done using the *measurement and compensation* mode of operation (referred to in the report as ‘M&C tamping’). In this:

- the tamping machine first makes a measurement run through the treatment site to record the existing track geometry (pre-work recording run);
- the on-board computer then calculates how the machine will lift and adjust the track in order to smooth the track geometry (the design);
- the machine then travels through the treatment site, lifting and adjusting the track in accordance with the design; and finally
- another measurement run is made to record the improved geometry (post-work recording run).

The Network Rail TQS supervising the work signs off the plant hire form (the PHIRES form) that records the work done and the averaged track geometry values measured, or calculated, during the pre-work, design and post-work phases. The completed form, together with a download of the geometry data from the on-board computer, forms a record of the improvement made and the post-work condition of the track. The TQS is also required to verify that no track geometry faults are left (paragraph 95); he uses a track gauge to make measurements of cant and *gauge*.

55 The maintenance work in December 2011 was carried out over three shifts: two night shifts (starting at 23:00 hrs on 24 December and 21:00 hrs on 25 December) and one day shift (starting at 9:00 hrs on 25 December). Separate Network Rail TQSs supervised the night and day shifts.

[11] Since the main and relief lines were classed track category 1A, NR/L2/TRK/001 required track geometry recording every four weeks.

56 The PHIRES forms show that the M&C tamping work was done in the following sequence: down main line, up main line, down relief line and finally up relief line. The order was adopted to prioritise geometry improvement to the higher speed lines (paragraph 10).

57 The Network Rail technical team that planned the maintenance did not require M&C tamping to be done on crossover 3717. Instead the tamping machine was to be used to *consolidate* the ballast under the timber bearers on the crossover, the track geometry being left in the condition resulting from the M&C tamping of the main and relief lines. Network Rail term this 'hardening up'. This approach would have avoided the risk of disturbing the improved geometry on the connected main and relief lines.

58 The hardening up on crossover 3717 was supervised by the TQS that worked the day shift on 25 December (paragraph 23). There was no post-work recording run to measure the resulting track geometry.

Identification of the immediate cause[12]

59 The immediate cause of the accident was that there was insufficient load on the front right-hand wheel of the leading bogie on wagon 24 to prevent its flange climbing over the railhead as the wagon passed over crossover 3717.

60 The following evidence supports this:

- The witness marks on the track (paragraph 47) show that the flanges of two wheels climbed over the railhead on the crossover, and then ran derailed to the right. The witness marks on the wheels and primary suspension lift stops (paragraph 35) showed that these were the two leading right-hand wheels on wagon 24.
- The RAIB estimated that the combined effect of the offset payload (the laterally offset cargo (paragraph 36) and the longitudinal position of the container WFHU 4147370 on wagon 24 (paragraph 18)) and the measured track twist (paragraph 45) caused wheel unloading that significantly exceeded the criterion[13] defined in the Railway Group standard GM/RT2141, 'Resistance of railway vehicles to derailment and roll-over'. This standard is used to assess the derailment risk of rail vehicles operating on Network Rail infrastructure. Neither the offset payload nor the track twist on their own resulted in the criterion being exceeded. There is evidence that both conditions were present at the time of the derailment.

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

[13] Flange climb derailments of this type occur when the ratio of the lateral force acting on the rail and the wheel load exceeds a critical limit value for a sustained period. A reduction in wheel load (wheel unloading) therefore increases the risk of derailment. According to GM/RT2141, wheel unloading on twisted track becomes unacceptable if, for any axle, the so-called 'delta Q/Q' ratio (the difference between the nominal wheel load (on level track) and the actual wheel load (on twisted track), divided by the nominal wheel load) exceeds 60%. While this criterion does not necessarily explain a flange climb derailment, it does indicate a risk. GM/RT2141 also defines the track twist to be used when testing rail vehicles.

61 The RAIB measured a *bogie frame twist* of 5 mm[14] when the leading bogie was examined after the derailment. Although this twist, if present before the derailment, would have contributed to the unloading of the front right-hand wheel, the wheel unloading criterion in GM/RT2141 would not be exceeded if the bogie twist combined with only one of the other effects (either the payload offset or the track twist). Furthermore, it is possible that the frame twist formed as a consequence of the bogie running derailed, in which case it played no part in the derailment.

62 The RAIB found no evidence that any other effects, such as a suspension defect or the way the train was being driven, contributed to the wheel flanges climbing over the railhead and into derailment.

Identification of causal factors[15]

63 The causes of the wheel unloading relate to:

- the offset payload on wagon 24, specifically the lateral offset of the cargo in container WFHU 4147370; and
- the track twist that wagon 24 encountered on crossover 3717 at Reading West Junction.

Neither alone would have caused unloading on the front right-hand wheel that exceeded the criterion in GM/RT2141; in combination they did (paragraph 60).

Wagon payload offset

64 **The offset loading on wagon 24, specifically the lateral offset of the payload in container WFHU 4147370 because it was not a normal condition, significantly reduced the load on the front right-hand wheel of wagon 24. This was a causal factor.**

65 Calculations show that the effect of the laterally offset cargo in container WFHU 4147370 was probably sufficient, in combination with the track twist, to unload the front right-hand wheel on wagon 24 beyond the criterion in GM/RT2141. They also show that the longitudinal position of the container (over the rear bogie) was also important in that it added to the degree of unloading and resulted in the criterion being exceeded by a significant margin (paragraph 60). However, the position of the container on the wagon was a normal condition permitted by Freightliner's loading standards. Furthermore, four other wagons on the train carried a single container on one end, and did not derail when passing over crossover 3717. The RAIB therefore concludes that the most significant factor in the uneven loading of the wagon was the lateral offset of the payload inside the container.

66 The pallets in the containers were unsecured in the container, and evidence indicates that they had moved to the left before the derailment. This resulted in a significant lateral load offset on wagon 24, an abnormal load condition.

---

[14] The bogie frame twist was measured over the bogie wheelbase: 2 m.

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

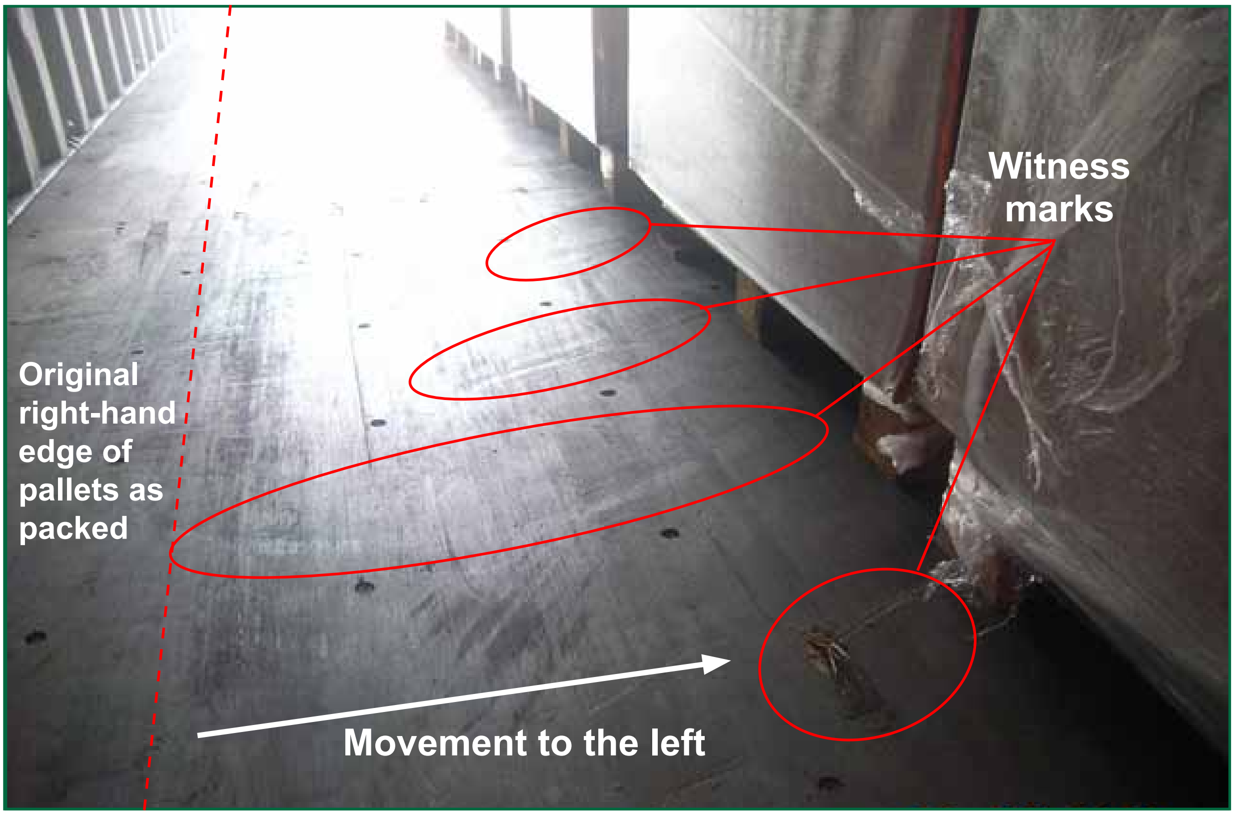


Figure 10: Witness marks on the floor of container WFHU 4147370 showing how the pallets moved

67 Marks on the container floor showed that the pallets moved uniformly to the left from a position near the longitudinal centre line (figure 10). This supports the warehouse assistant's recollection that he had packed them centrally in the container (paragraph 26 and figure 4).

68 Given the smooth and continuous nature of the marks, for this movement to have occurred the pallets would need to have been subjected to a sustained lateral acceleration, which was sufficient to overcome the friction between the wood pallets and the wood floor of the container. Shorter and intermittent marks would be more consistent with the pallets moving after the derailment when the wheels would have been running roughly over ballast, timber bearers and rail fastenings. There was no evidence of this.

69 Road tests, simulating the route taken by the lorry that delivered the container to Lawley Street terminal, showed high sustained lateral accelerations that would have caused movement to the left are more common than those that would cause movement to the right. Furthermore the sustained lateral acceleration levels measured were significantly greater than those that would be experienced during rail transport[16]. This, together with station CCTV images suggesting the container was slightly tilted to the left on its journey between Lawley Street and Reading West Junction[17], supported the conclusion that the pallets had moved during the road journey and therefore before the container was loaded onto train 4O02. The road haulier reported that the lorry driver was unaware of this.

[16] Network Rail's Track Design Handbook (NR/L2/TRK/2049) specifies that train speed and track design shall be such that the *cant deficiency* or *cant excess* experienced by conventional (non-tilting) trains does not exceed 150 mm (180 mm in exceptional cases). This is equivalent to a lateral acceleration of approximately 1.0 m/s^2. Sustained acceleration levels more than three times this level were measured on the road tests.

[17] The amount of tilt was slight, and not possible to detect on all CCTV images. However, where it was apparent, it consistently supported the container being more heavily loaded on the left-hand side.

Container packing

70 Schaeffler did not have a process for packing containers that ensured the pallets would not move during transit. This was a factor.

71 The warehouse assistant stated that he was used to having just enough pallets to cover the entire container floor. This was not the case with container WFHU 4147370[18] and he was left to use his experience to decide how best to stow the 13 pallets (paragraph 26).

72 Schaeffler provided detailed instructions on how to package the pallets themselves (such as carton type and labelling). However, it did not issue anything similar regarding how the pallets should be packed into a container, and provided no related staff training.

73 The RAIB identified a variety of documents giving guidance on the safe packing of freight containers (paragraphs 37 to 42). Nearly all emphasise the need to ensure that the payload is secure and that its centre of gravity is not significantly offset. Some, notably the IMO/ILO/UNECE guidelines, give practical advice on securing the payload and highlight the need for training (paragraph 39).

74 The ILO published a research report for discussion at a forum it convened in Geneva in February 2011[19]: 'Global dialogue forum on safety in the supply chain in relation to packing of containers'. Government, employer and worker representatives from various countries attended, including the UK.

75 The research report included the results of a telephone survey of 52 UK freight forwarding companies. It revealed that only 23% were aware of the IMO/ILO/UNECE guidelines, and most had not heard of several other documents identified. There was a consensus at the forum that a lack of awareness of existing standards and guidelines was a reason leading to the poor packing of containers. There was also a consensus on ways in which this could be improved. Schaeffler reported that it was unaware of the IMO/ILO/UNECE guidelines, or similar documents.

Container handling and loading

76 The method that Freightliner used to handle container WFHU 4147370 at its Lawley Street terminal did not detect that it was very unevenly loaded before it was loaded onto train 4O02. This was a probable factor.

77 As is normal inter-modal freight practice, container WFHU 4147370 was already sealed when it arrived at the Lawley Street terminal, and Freightliner staff reported that containers are not opened unless a specific concern is identified. In the standard conditions of carriage that Freightliner uses when contracting to transport a container[20], customers are required to warrant the suitability of the 'manner of packing, stowage and securing' within the container. The standard conditions also require customers to notify Freightliner if cargo is 'stowed in an asymmetrical manner'.

[18] Schaeffler had requested a 40 foot long container so the 13 pallets could be packed without stacking.

[19] The research report, 'Safety in the supply chain in relation to packing of containers' and the final report of the forum are available at www.ilo.org.

[20] The RAIB examined these conditions to understand the criteria generally used to assure the safe packing of containers. It did not determine the degree to which these criteria were applied.

78 Prior to the train pre-departure checks, Freightliner's only routine opportunity to identify an uneven payload was if it had lifted container WFHU 4147370 using one of the mobile *reachstackers* on the terminal (figure 11a). Since these have pivoting lifting equipment, operators are able to identify a laterally offset payload since the container will tilt when it is lifted (the inset to figure 11 shows how container WFHU 41417370 tilted when it was lifted off the train with a reachstacker at Southampton Maritime). However, container WFHU 4147370 was taken straight to the track side, and lifted onto the train using one of the two main overhead cranes (figure 11b). Freightliner reported that neither of these cranes can detect offset container loads, and that containers remain level during lifting.

Figure 11: Reachstacker and overhead crane at Lawley Street terminal (inset shows container WFHU 4147370 tilted when it was lifted with a simlar reachstacker at Southampton Maritime)

Train pre-departure checks

79 The pre-departure checks at Lawley Street terminal rely solely on visual examination to identify unevenly loaded wagons. This was a possible factor.

80 Freightliner document OPS-IM/008, 'Rail Operations Manual', defines the necessary pre-departure checks for a container train. Appendix 1 of the document gives guidance on the individual checks. The guidance is broadly consistent with the checklist that the shift supervisor signed before the train departed (paragraph 29), and includes the need to confirm that 'all vehicles appear to have been loaded evenly'.

81 The shift supervisor reported that he makes this check by walking around the train and looking for any telltale signs, such as misaligned buffers and unevenly compressed springs. However, given the observations made when the train was examined after the derailment (paragraph 36) and the station CCTV images from its journey (paragraph 69), container WFHU 4147370 on wagon 24 would only have been tilted a small amount. It would therefore have been very difficult even for a very highly observant member of staff to notice the laterally offset load.

82 There is no system at Lawley Street for measuring the individual or side-to-side wheel loads on a wagon before it leaves the terminal. Freightliner has no such system at its other inter-modal freight terminals, and is not aware of any in use at any other similar terminals in the UK.

Track twist

83 **The *twist fault* on crossover 3717, which was of a level at which Network Rail permitted trains to continue to run, went undetected and caused a significant load reduction on the front right-hand wheel of wagon 24 as it passed over. This was a causal factor.**

84 The post-derailment track survey revealed a track twist of 1 in 188 on crossover 3717 (paragraph 45). While this exceeded the 1 in 200 limit that Network Rail's standard NR/L2/TRK/001 requires to be repaired in 14 days[21], it was less than the 1 in 90 limit for which the standard requires the line to be immediately blocked to traffic. It was therefore a condition that Network Rail allows to exist for a limited number of days, and a track feature that any vehicle could expect to encounter. Calculations indicate, however, that it was large enough to increase the unloading on the already lightly loaded front right-hand wheel on wagon 24 beyond the criterion in GM/RT2141 (paragraph 60).

85 The post-incident track survey was made with the track in the unloaded condition, and did not account for deflection due to train weight (paragraph 43). It is therefore possible that the track twist under wagon 24 may have been worse.

86 Network Rail's routine track inspection process did not identify the track twist in the period between the mechanised maintenance work in December 2011 (paragraphs 54 to 58) and the derailment. It would also have been unable to reliably identify it in the future - even if it had become more severe.

87 It is possible that a twist fault was left on crossover 3717 after the mechanised maintenance work and its presence was not identified by the supervising TQS. However, although rapid degradation following the mechanised maintenance is probably unlikely, the possibility that the twist deteriorated from a compliant level cannot be excluded.

Routine track inspection

88 **Network Rail's routine track inspection process did not identify that a twist fault had developed on crossover 3717. This was a factor.**

89 NR/L2/TRK/001 defines Network Rail's process for routine track inspection. It essentially relies on two means of identifying track twist faults: track geometry recording and visual inspection.

90 Track geometry recording is the primary means. It offers the opportunity to make quantitative continuous measurements of the track and the automatic identification of notifiable discrete geometry faults. As Network Rail normally uses a track measurement train, the track is usually measured under load.

[21] Network Rail's repair times for twist faults are based on an assessment of risk. A track twist of 1 in 90 is considered to represent a high risk, and therefore needs to be rectified before trains are allowed to run again. A track twist of 1 in 200 still presents a significant risk that needs to be rectified quickly, but trains can continue to run in the meanwhile. The risk associated with a track twist of 1 in 250 is considered low, and it is acceptable for it to be repaired during normal planned maintenance.

91 However, on crossover 3717 Network Rail decided that no routine geometry recording was required (paragraph 53), and so none was done (although monitoring of the geometry was still required as part of the supervisor visual track inspection (paragraph 50)). The decision was based on a requirement in the issue of NR/L2/TRK/001 that was current at the time[22]. This stated that recordings need to be made on 'long crossovers with more than five sleepers (or short bearers of sleeper length) between the through timbers (or bearers) on the crossover road'. Crossover 3717 had no sleepers between the timber bearers (through timbers) connecting it to the up main and down relief lines (paragraph 46 and figure 9); it therefore did not meet this criterion. At the time Network Rail considered that the risk of a twist fault forming on shorter crossovers was low.

92 The last supervisor's and track maintenance engineer's inspections (paragraphs 50 and 51) were done before the mechanised track maintenance work. Because this work would have almost certainly changed the geometry on the crossover (paragraph 103), the patroller's weekly basic visual inspection was likely to be the last detection opportunity. However, the twist fault was not very severe and it would probably be unreasonable to expect a patroller to have detected it by eye, and the inspection reports showed that none of the patrollers did (paragraph 49).

93 No cab riding was done over crossover 3717 (paragraph 52). Even if it had been, it would not necessarily have detected the twist fault.

Recent mechanised track maintenance work at Reading West Junction

94 **A twist fault may have been left on crossover 3717 on completion of mechanised track maintenance in December 2011, which was not identified. This was a possible factor.**

95 Among other duties, Network Rail standard NR/L3/TRK/3230, 'Control of machines', requires the TQS to:

- take 'suitable and sufficient' track geometry measurements during machine operation to 'enable any anomaly to be detected'; and
- after the work is complete, verify that the track geometry is 'within mandated maintenance limits.'

96 The TQS who supervised the hardening up on crossover 3717 (paragraph 58) recalled checking for track twist on the crossover, but he found nothing of concern. He made no record of the measurements he took, and was not required to do so.

97 Had the twist fault been present after the work, the following possibilities could explain why it was not found:

- The TQS's checks for track twist involve the need for repeated manual calculation and then comparison with defined maintenance limit values. This is a potentially monotonous process that is prone to arithmetical error.
- It is not clear in Network Rail's standards[23] how regularly the TQS should use his track gauge when checking for twist faults. It may have been so localised that the measurement locations he used did not reveal it.

[22] Issue 4, dated 5 December 2009.

[23] NR/L3/TRK/3230, 'Control of machines', and NR/L3/TRK/002/E01, 'Track maintenance handbook: S&C tamping'.

98 In addition, the RAIB observed that TQSs use a track gauge to measure the track geometry during and after mechanised track maintenance work. Therefore they measure the track in the unloaded condition and are unable to detect geometry faults that are only revealed when the track is deflected by the weight of the train. The post-work recording run (paragraph 54) done as part of M&C tamping could give the TQS the opportunity to look for geometry faults[24] with the track under load. However, on crossover 3717 only hardening up was done, and no such recording run was made. Neither Network Rail's standards nor its training course for TQSs state whether a post-work recording run is necessary after hardening up.

Additional observations

WheelChex

99 *WheelChex* is a type of Wheel Impact Load Detector (WILD) system. Both rails on a straight and level section of track are instrumented and measure the load imparted by a moving wheel. The primary function of WheelChex is to identify vehicles with wheels that are generating excessive forces on the rail, such as wheels that have flat spots or are out-of-round, so that they can be stopped before they damage the infrastructure. WheelChex also has the capability to detect uneven wheel loads, indicating the degree of imbalance between left- and right-hand wheel loads (such as might occur in the case of a defective wagon).

100 When the RAIB investigated derailments involving uneven wagon wheel loads at King Edward Bridge, Newcastle upon Tyne (report number 02/2008[25]), and Ely (report number 02/2009) it found that Network Rail had no mechanism to advise train operators of the imbalanced wheel loads that WheelChex had detected. Given this, the RAIB felt that wheel load data collected by WheelChex could be more effectively used to manage the risk posed by defective wagons, and made corresponding recommendations on Network Rail. The Office of Rail Regulation has subsequently reported that Network Rail is implementing a new WILD system, known as 'Gotcha', and as a result has closed these recommendations. Network Rail has informed the RAIB that full implementation of the 'Gotcha' system, at around 30 sites on its network, is scheduled for completion in 2015. It has also confirmed that the system will have the functionality to monitor wheel load differences diagonally between two axles, and will therefore be able to detect such defective wagons.

101 The uneven wheel loads on wagon 24 on train 4O02 were due to the condition of its payload rather than a defect with the wagon. Train 4O02 passed only one WheelChex site before the derailment: Cholsey, 20 km north-west of Reading West Junction. However, the detection system there was not operating because of ongoing track relaying work in the area.

---

[24] The post-work recording run makes a continual measurement of the track geometry that is displayed as a set of graphical traces on the tamping machine's computer. The machine used in December 2011 was not calibrated to automatically alert the operator to track defects that exceeded Network Rail's maintenance limits. However, it should be possible to identify such significant faults from the shapes of the relevant traces.

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

102 If Network Rail had had a WILD system on the route of train 4O02 that was operational and capable of alerting the signaller, it is possible that the derailment could have been averted. However, the RAIB considers that reliance on such systems should not be a primary control of the risks associated with offset payloads. This is because the sparse distribution of WILD systems will mean that it may not be possible to detect at-risk wagons in sufficient time to avert a derailment. It is for this reason that the RAIB's recommendations in this area have focused on checks that can be made before wagons enter traffic.

Tamping areas of S&C

103 The use of a single tamping machine to do M&C tamping on through lines in areas of S&C (paragraphs 54 and 56) may result in differential vertical adjustment of adjacent tracks. At Reading West Junction, Network Rail engineers surveyed the track for the RAIB and found that a height difference of nearly 100 mm had developed between the up main and the down relief lines in the vicinity of the derailment. Because of the connecting timber bearers, these differential adjustments risk the formation of cant and vertical geometry variation on local crossovers (and similar sections of track) and, as a result, track twist. Network Rail uses this method of mechanised track maintenance at many other junctions.

Previous occurrences of a similar character

104 The RAIB has investigated a number of freight train derailments having similar characteristics:

- Washwood Heath, Birmingham, 8 September 2006. A wagon on a 17-wagon container train derailed on a crossover as the train departed from Washwood Heath sidings. There was limited damage.
- King Edward Bridge, Newcastle upon Tyne, 10 May 2007 (paragraph 100). Two wagons on an empty 26-wagon coal train derailed on a crossover south of King Edward Bridge. Other wagons subsequently derailed and there was considerable damage to the track on the southern approach to Newcastle station.
- Duddeston Junction, Birmingham, 10 August 2007. Two wagons of a 24-wagon container train derailed on a crossover as the train departed the inter-modal freight terminal at Lawley Street. Wagons and displaced containers ended up foul of adjacent running lines and there was considerable damage to the track.
- Moor Street, Birmingham, 25 March 2008. Four wagons of an empty 30-wagon scrap metal train derailed, south-east of Moor Street station, approaching points on a viaduct. There was significant damage to the train and infrastructure. Part of the viaduct parapet was demolished and fell onto an unoccupied car below.

105 All of the derailments listed above involved a track twist in an area of S&C, and three were on crossovers. The derailment at Duddeston Junction is the most similar. It involved an unevenly loaded FEA type wagon that carried a container with a payload that was possibly laterally offset.

106 The RAIB is aware of two more recent container train derailments. One was on 2 May 2012 on sidings in Felixstowe docks, Suffolk; the other was on 1 August 2012 on the Kingsbury Branch freight line north-east of Birmingham. Neither was on, or blocked, a line that was open to railway traffic. Although the RAIB is not investigating either incident, information from the railway industry indicates that in both cases the wagons were unevenly loaded.

Summary of conclusions

Immediate cause

107 The immediate cause of the accident was that there was insufficient load on the front right-hand wheel of the leading bogie on wagon 24 to prevent its flange climbing over the railhead as the wagon passed over crossover 3717 (**paragraph 59**).

Causal factors

108 The causal factors were:

a. The offset loading on wagon 24, specifically the lateral offset of the payload in container WFHU 4147370 because it was not a normal condition, significantly reduced the load on the front right-hand wheel of wagon 24 (**paragraph 64, Recommendations 1, 2 and 3**).

The following factors relate to this:

i. Schaeffler did not have a process for packing containers that ensured the pallets would not move during transit (**paragraph 70, Recommendation 1**).

Probable factor:

ii. The method that Freightliner used to handle container WFHU 4147370 at its Lawley Street terminal did not detect that it was very unevenly loaded before it loaded was onto train 4O02 (**paragraph 76, Recommendations 2 and 3**).

Possible factor:

iii. The pre-departure checks at the Lawley Street terminal rely solely on visual examination to identify unevenly loaded wagons (**paragraph 79, Recommendations 2 and 3**).

b. The twist fault on crossover 3717, which was of a level at which Network Rail permitted trains to continue to run, went undetected and caused a significant load reduction on the front right-hand wheel of wagon 24 as it passed over (**paragraph 83**).

The following factors relate to this:

i. Network Rail's routine track inspection process did not identify that a twist fault had developed on crossover 3717 (**paragraph 88**).

Possible factor:

ii. A twist fault may have been left on crossover 3717 on completion of mechanised track maintenance in December 2011, which was not identified (**paragraph 94, Recommendation 4**).

Additional observations

109 The reliance on a track gauge to measure and quantify the track geometry during and after mechanised track maintenance work means that a TQS cannot reliably identify twist faults that are only revealed when the track is loaded. A post-work recording run using a tamping machine could offer the TQS an opportunity to observe such faults. However, there is a lack of clarity as to whether these recording runs are necessary after hardening up work (**paragraph 98, Recommendation 4**).

110 Undertaking mechanised track maintenance in areas of S&C with a single tamping machine using the M&C mode of operation risks track twists forming on local crossovers, and similar sections of track (**paragraph 103, Recommendation 5**).

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

111 Schaeffler has developed and published a procedure for packing freight containers. This requires that, if there are not enough pallets to cover a container floor (partial loads), the cargo is securely stowed and its weight is evenly distributed. It has provided the equipment necessary to achieve this. This action has avoided the need for the RAIB to make an organisation-specific recommendation to address a factor in this investigation (paragraph 108a.i).

112 Network Rail has repaired the twist fault that it found on crossover 3717. It has also re-planned one of the measurement schedules for one of its track measurement train runs so that it routinely records the track geometry on crossover 3717.

113 Network Rail has recently made significant changes to NR/L2/TRK/001 and, on 1 December 2012, published issue 6. These changes include reworded requirements for track geometry recording that make it evident that routine track geometry recording is now neccessary on crossovers like crossover 3717. This action has removed the need for the RAIB to make recommendations to address two factors in this investigation (paragraphs 108b and 108b.i).

Recommendations

114 The following recommendations are made:[26]

1 *The intention of this recommendation is to make shippers and freight forwarders aware of published guidelines for the safe packing of freight containers. Following these guidelines ensures that the cargo within a sealed container remains evenly loaded and secure. Recent research indicates that the UK freight industry is not fully aware of the guidelines.*

The Heath and Safety Executive should identify and use the most appropriate means to make shippers and freight forwarders aware of the need to pack freight containers in accordance with the 'Guidelines for packing of cargo transport units', published by the International Maritime Organization, or an equivalent document.

By the same means, it should also remind organisations of the need to have operational procedures, resources, equipment and training in place to ensure that cargo is evenly loaded and secure.

The Heath and Safety Executive should also make other national and international safety regulators aware of the findings of this investigation and highlight the need to follow the guidelines (paragraphs 108a and 108a.i).

continued

[26] 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 Health and Safety Executive and the Office of Rail Regulation to enable them to carry out their duties under regulation 12(2) to:

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

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

Copies of both the regulations and the accompanying guidance notes (paragraphs 167 to 171) can be found on RAIB's website www.raib.gov.uk.

2 *The intention of this recommendation is that rail freight and inter-modal freight terminal operators have arrangements in place to manage the risk associated with allowing poorly packed freight containers on the railway. Recognising that many of the indications of poor packing are hidden, operators should require that their customers give assurance that containers are packed in accordance with recognised good practice (eg the IMO/ILO/UNECE guidelines) and carry out appropriate audits to verify this. Where there is no assurance, operators should make physical checks to confirm the evenness of the load.*

Freightliner should review its operating procedures and conditions of carriage for freight containers. It should then implement any changes necessary to require that (paragraphs 108a, 108a.ii and 108a.iii):

- senders provide certification sourced from the relevant party, or have equivalent procedural arrangements in place, which confirm that freight containers offered for transit have been packed in accordance with the 'Guidelines for packing cargo transport units', published by the International Maritime Organization, or an equivalent document;
- the effectiveness of such certification or procedural arrangements are periodically audited, with remedial action taken as needed;

and that where such arrangements are not in place:

- alternative action is taken to confirm that the cargo in a container is both evenly and securely stowed.

This recommendation may also be applicable to other operators of rail freight services and inter-modal freight terminals.

3 *The intention of this recommendation is for inter-modal freight terminal operators to develop requirements and investigate introducing a suitable monitoring system, for use during routine container and train handling, to prevent freight container wagons entering traffic with a side-to-side wheel load imbalance. The system could be based on the measurement of individual or side-to-side wheel loads prior to the train entering traffic or the identification of freight container load offsets during lifting.*

Freightliner should develop requirements for a system to monitor and prevent load offsets from containers resulting in wagons with a side-to-side wheel load imbalance entering traffic from its terminals. The system should be considered when terminal equipment is planned to be installed or upgraded, and where practicable the system should be implemented (paragraphs 108a, 108a.ii and 108a.iii).

This recommendation may also be applicable to other operators of inter-modal freight terminals.

continued

4 *The intention of this recommendation is to prevent track geometry faults being undetected after mechanised track maintenance work is completed. The need for a TQS to inspect and measure the track during and after this work is an important opportunity to identify faults that have formed, or existed beforehand. Recognising that current inspection arrangements may not result in reliable detection, Network Rail should assess and implement practical improvements. These could include consideration of the continuous recording of track geometry using approved manual methods (with allowance made for track deflection due to vehicle loading) and taking full advantage of the track measurement capabilities of tamping machines and similar track maintenance plant.*

Network Rail should review and, where necessary, improve its processes for the detection of track geometry faults after mechanised track maintenance work to reduce the likelihood of such faults going undetected before the railway is handed back into service (paragraphs 108b.ii and 109).

5 *The intention of this recommendation is for Network Rail to review its current processes for mechanised track maintenance, and develop and make available best practice guidelines that minimise the formation of geometry faults on crossovers and similar sections of track.*

Network Rail should establish best practice guidelines for mechanised track maintenance work in areas of switches and crossings that minimise the risk of track twist and other geometry faults forming, and remaining on, crossovers and similar sections of track. It should make its track maintenance teams aware of these and the importance of following them, wherever practicable (paragraph 110).

Appendices

Appendix A - Glossary of abbreviations and acronyms

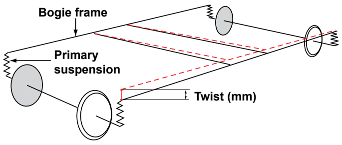
CCTV	Closed Circuit Television
CTU	Cargo Transport Unit
ILO	International Labour Organization
IMO	International Maritime Organization
ISO	International Organization for Standardization
M&C	Measurement and Compensation
OTDR	On-Train Data Recorder
S&C	Switches and Crossings
TQS	Track Quality Supervisor
TME	Track Maintenance Engineer
UNECE	United Nations Economic Commission for Europe
WILD	Wheel Impact Load Detector

Appendix B - Glossary of terms

All definitions marked with an asterisk, thus (*), have been taken from Ellis's British Railway Engineering Encyclopaedia © Iain Ellis. www.iainellis.com.

Baseplate A cast or rolled steel support for flat-bottom rails.*

Bogie frame twist Distortion of the structural frame on a bogie that results in the one of the primary suspension connection points being out of plane with the others.



Cab riding Inspections carried out from the driving cab of a rail vehicle (typically in normal service) in order to observe the track and lineside, and gain a qualitative appreciation of ride quality.

Cant The amount by which one rail on the track is raised above the other.*

Cant deficiency The amount that the track cant needs to increase in order to balance the centrifugal force acting on a rail vehicle when running at speed on a curve.

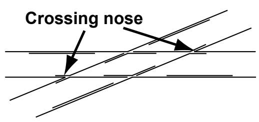
Cant excess The amount that the track cant needs to decrease in order to balance the centrifugal force acting on a rail vehicle when running at speed on a curve.

Cargo transport unit General term used to describe a freight container, vehicle, railway wagon or similar unit that is used to transport goods.

Consolidate Compacting of the ballast under the rails to remove voids.

Continuously welded Continuous long lengths of rail made by welding together shorter lengths.

Crossing nose The apex of the v-shaped track component that is located where the two rails cross at a diamond crossing.



Crossover A short section of connecting track, with points at both ends, that permits trains to move from one line to another.

Diamond crossing A point at which two railway lines intersect, but where trains cannot be switched from one line to another.

Down In the direction away from London.

Flat-bottom A type of rail characterised by a broad and shallow base or 'bottom'.

Flyover A bridge at a railway junction that carries a diverging line over the main line at a higher level.

Freight forwarder A company or individual that organises the shipment of goods on behalf of a customer.

Freight operating company	A company that operates freight trains on the railway.
Gauge	The distance between the inside faces of the rails.
Great Western Main Line	The route from London (Paddington) to Penzance via Reading and Bristol.*
Inter-modal freight terminal	A facility where freight containers are transferred from one mode of surface transport to another (eg from road to rail).
International Labour Organization	The agency of the United Nations with responsibility for drawing up and overseeing international labour standards.
International Maritime Organization	The agency of the United Nations with responsibility for the safety and security of shipping and the prevention of marine pollution by ships.
International Organization for Standardization	Worldwide federation of national standards bodies that develops and publishes international technical standards.
Landing	Lowering a freight container onto the ground or equivalent surface.
Lifting and packing	The action of raising the track to its designed level and adding compacted ballast beneath the sleepers. The term is normally associated with a manual operation involving ratchet jacks and shovels, but can include tamping.*
Measurement and compensation	A method of tamping whereby the tamping machine calculates the amount the track is to be lifted and re-aligned from measurements made on site.
On-train data recorder	A data recorder fitted to a train that records information on the status of train equipment, including speed and brake applications.
Pandrol clip	A rail clip that secures flat-bottom rail to sleeper fixings.
Patroller	A person who carries out a visual inspection of the line.
Pre-departure check	A physical examination of a freight train that is undertaken before it is allowed to run on the railway.
Primary suspension lift stop	A mechanical device to limit the movement between the axlebox and bogie frame. These devices are also used to retain wheelsets during bogie lifting.
Reachstacker	A self-propelled vehicle, with a hydraulically operated telescopic boom, that is used for lifting and moving freight containers.

Recording traces	Graphical output from the track measurement train that shows the amplitude of track geometry features (such as cant, gauge, lateral alignment) against distance along the track.
Shunting	The act of moving vehicles within a defined locality for the purpose of constructing or splitting trains, or positioning vehicles for work activities.*
Supervisor	The manager responsible for ensuring that the track remains safe for operational use.
Switches and crossings	Track that allows trains to move from one line to another.
Tamping	The operation of lifting the track and simultaneously packing the ballast beneath the sleepers in order to improve the track geometry.
Tamping machine	An engineering vehicle that is used for tamping the track.
Thames Valley Signalling Centre	An electronic control centre system located at Didcot that currently controls signals: ● from London Paddington to just beyond Heathrow Airport Junction; ● in the Reading area; and ● on the majority of the line between Reading and Westbury.
Timber bearers	A wooden beam used to support the track.*
Track circuit	An electrical circuit in the running rails that detects the presence of a train.
Track gauge	A manual gauge that measures the horizontal distance between the rails (gauge), and the vertical difference between the rails (cant).
Track Maintenance Engineer	The Network Rail manager responsible for the delivery of track maintenance, and the line management of supervisors, within a defined area.*
Track measurement train	A train used for gathering quantitative data about the track geometry on a line. Typically the data recorded includes: alignment, cant, radius, top (vertical position) and twist.
Track quality supervisor	Network Rail employee responsible for: ● supervising mechanised track maintenance work; and ● confirming that, on completion of such work, the track condition is such that lines can be re-opened to traffic.
Track twist	The change in cant, along the track, measured over a specific distance.

Trailed	To pass through points in the converging direction, when the points are not set for that vehicle movement. In the process, wheels force the closed switch rail apart.
Train document	A computer-generated document giving information about a train such as: its identification number; departure time; origin; destination; maximum load; length and maximum speed. The computer automatically checks the information to confirm whether the train formation conforms to prescribed criteria and standards.
Train preparation	Pre-departure duties which include checking: the train for compliance with the train document; all vehicles to ensure that they are properly coupled; that the necessary lamps are provided; that all vehicles appear safe to travel; and that all handbrakes are released.*
Twist fault	A track twist that exceeds limits defined for track maintenance purposes.
United Nations Economic Commission for Europe	Regional commission of the United Nations with the aim of promoting pan-European economic integration. Members include representatives from Europe, the former Soviet Republics and North America.
Up	In the direction of London.*
WheelChex	A proprietary system for detecting wheel flats and 'out-of-round' effects, and measuring wheel loads of passing trains.

Appendix C - Guidance and standards for packing freight containers

IMO/ILO/UNECE guidelines for packing of cargo transport units	Available at: www.unece.org ISBN 92-801-1443-3
ISO 3874, 'Series 1 freight containers – Handling and securing'	Available at: www.iso.org
BS 5073, 'British Standard guide to stowage of goods in freight containers'	Available at: shop.bsigroup.com
'European best practice guidelines on cargo securing for road transport'	Available at: ec.europa.eu
'Code of practice – safety of loads on vehicles'	Available at: www.tsoshop.co.uk ISBN 011 552547 5
'Safe transport of containers by sea – industry guidance for shippers and container stuffers'	Available at: www.worldshipping.org
'Working with containers – an FTA best practice guide'	Available at: www.fta.co.uk

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

Telephone: 01332 253300
Fax: 01332 253301
Email: enquiries@raib.gov.uk
Website: www.raib.gov.uk