Rail Accident Investigation Branch

Rail Accident Report

Derailment at Primrose Hill / Camden Road West Junction
15 October 2013

Report 21/2014
October 2014

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.

(Cover image courtesy Network Rail)

Derailment at Primrose Hill / Camden Road West Junction, 15 October 2013

Contents

Summary

At about 02:40 hrs on 15 October 2013, a freight train travelling from Birmingham to Felixstowe derailed close to the site of the former Primrose Hill station in north-west London. There were no injuries as a consequence of the accident, although there was damage to the train and to railway infrastructure. The North London route, which carries London Overground passenger services as well as freight trains, was subsequently closed for six days.

One wagon in the train ran derailed until the train reached a junction near Camden Road station. At this point, an empty container toppled off the wagon and damaged overhead line electrification equipment. The derailment was caused by a combination of the track geometry and condition, as well as the longitudinal and lateral asymmetric loading of the wagon which reduced its resistance to derailment on twisted track.

The RAIB has made three recommendations. These cover:

- the provision by Network Rail of guidance to managers responsible for track maintenance on the actions to be taken if measurements by track recording vehicles do not take place as planned;
- consideration of the factors that contribute to the derailment of unevenly loaded container wagons, and the associated risk, with cross-industry evaluation of the case for additional measures to mitigate the risk; and
- the clarification by RSSB of the requirements for the design and acceptance of freight wagons.

As a learning point from this accident, the RAIB has also identified that Network Rail should give particular attention to the possible consequences of a high turnover of responsible staff during reorganisations.

Introduction

Preface

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

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

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

Key definitions

4 Dimensions in this report are generally given in metric units, except for speeds and distances which are given in imperial units in accordance with normal railway practice. The dimensions of containers are also given in imperial units, in accordance with normal shipping industry practice. Where appropriate the equivalent metric value is also given.

5 References to the North London lines in this report are to the lines running from Camden Junction to Camden Road West Junction via Primrose Hill Junction (figure 3). The terms 'Up' and 'Down' are relative to the direction of travel; the Up North London line runs east from the junction with the West Coast Main Line, at the exit from Primrose Hill Tunnel, towards Stratford. Distances are measured from the former Broad Street station.

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

The accident

Summary of the accident

7 At about 02:40 hrs on 15 October 2013, the 23:03 hrs Freightliner *intermodal train* from Birmingham Lawley Street to Felixstowe, train reporting number 4L77, derailed close to the former Primrose Hill station (figure 1).

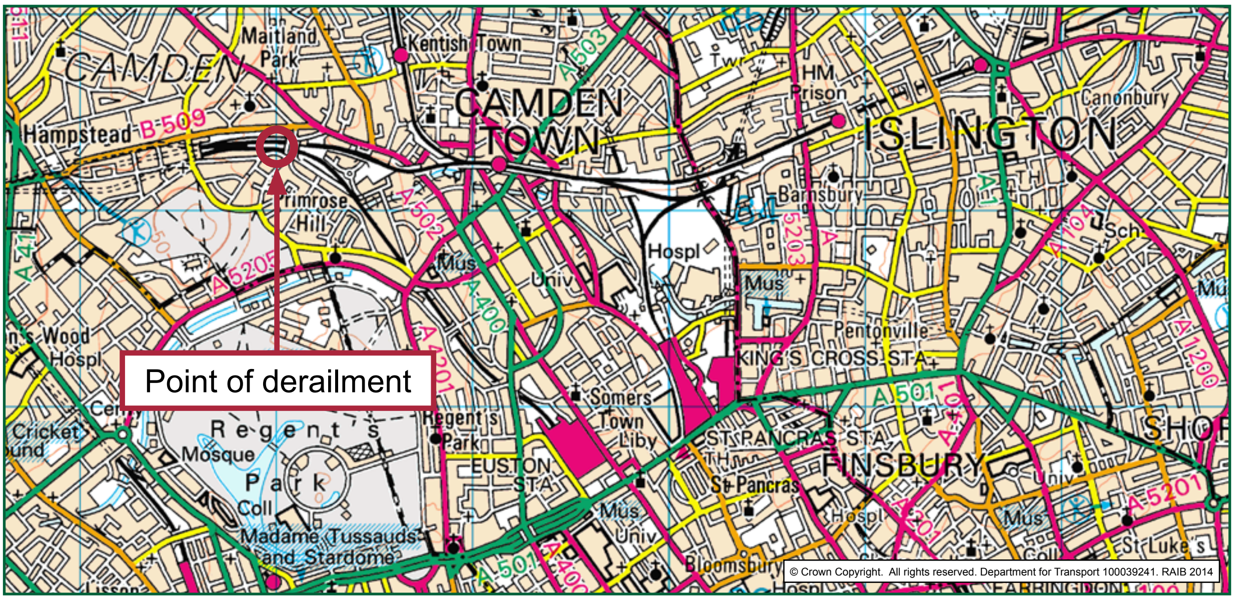


Figure 1: Extract from Ordnance Survey map showing location of derailment

8 The rear bogie of the fifth wagon derailed on curved plain line. The wagon ran derailed for approximately 0.6 miles (0.9 km) before reaching Camden Road West Junction (figure 2), at which point the leading bogie of the same wagon also derailed and an empty container toppled from the wagon. The train stopped shortly afterwards, when its brakes applied automatically due to the damage it had sustained when the leading bogie derailed.

9 There were no injuries as a consequence of the accident, although there was damage to the track, electrification equipment, a viaduct wall, the derailed wagon and the containers it was carrying. The Up and Down North London lines were subsequently closed for six days.

Context

Location and infrastructure

10 The Up and Down North London lines connect the West Coast Main Line with the orbital North London route that carries freight and London Overground passenger services. The section of line between Camden Junction and Camden Road West Junction is approximately 0.9 miles (1.4 km) long (figure 3); its length is split approximately equally between Network Rail's London North Western (South) (LNW(S)) and Anglia *Routes*. It is predominantly used for freight traffic, although it is also used by excursion trains and as a diversionary route for scheduled passenger services. It is therefore classified by Network Rail as a passenger line.

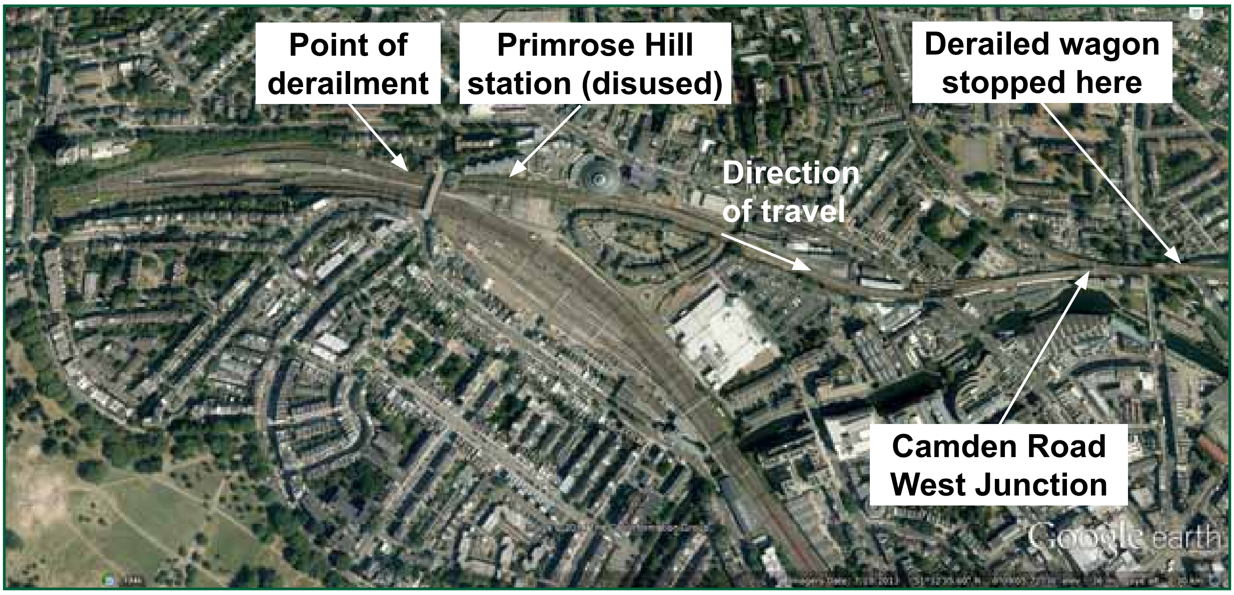


Figure 2: Aerial view of accident location

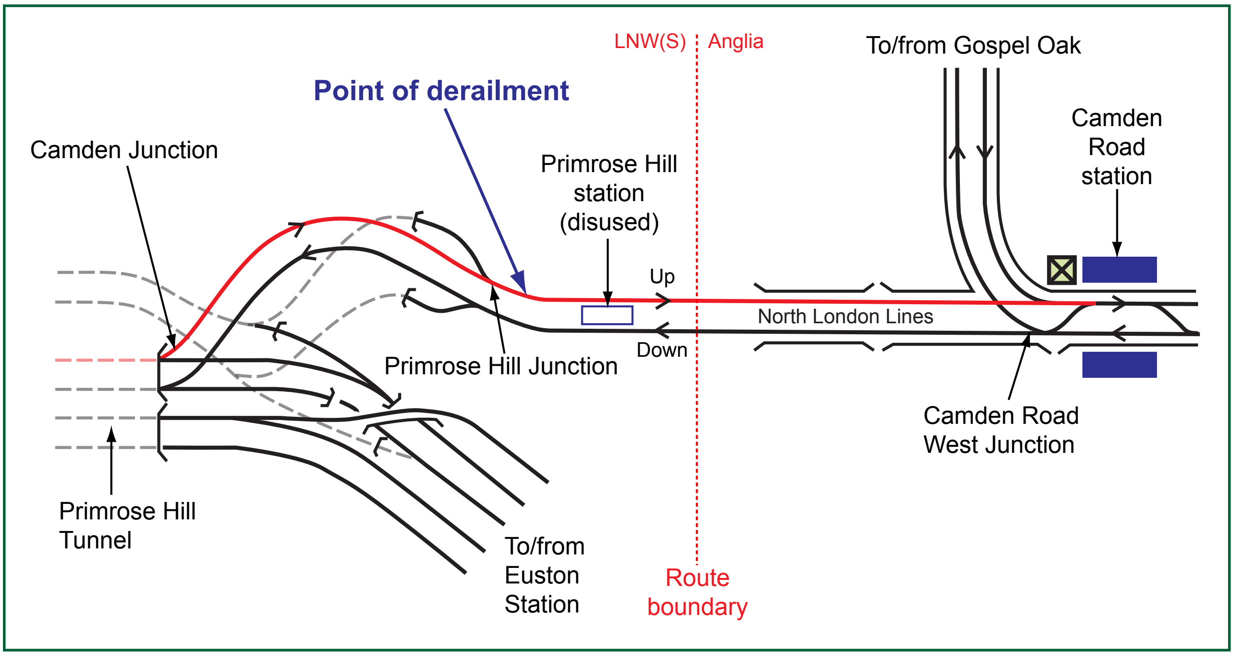


Figure 3: Track layout

11 The point of derailment was on the approach to the site of the former Primrose Hill station (figure 3), 220 yards (200 metres) on the LNW(S) side of the Route boundary. It was on a left-hand curve with a radius of approximately 190 metres. The track in the vicinity of the point of derailment consisted of jointed rail, with a mixture of concrete and timber sleepers. Trains are limited to a maximum speed of 15 mph (24 km/h) through the area.

Organisations involved

12 Network Rail is the owner of the railway infrastructure at Primrose Hill and Camden Road. It employs the staff who were responsible for the maintenance of the track in the area where the train derailed.

13 Freightliner was the operator of train 4L77 and employs its driver. It had also loaded the containers onto the wagons at its Lawley Street depot in Birmingham.

14 Beaver Metals had packed the leading container on the derailed wagon with scrap metal.

15 All of the organisations involved freely co-operated with the investigation. Assistance was also provided to the RAIB by GB Railfreight, which operates a significant number of FEA wagons similar to the type that derailed.

Train involved

16 Train 4L77 consisted of a class 70 locomotive (No. 70007) and twenty-two loaded *flatbed wagons*[1]; these wagons were a mix of FEA, FSA/FTA and FWA types.

17 The wagon that derailed, No. 641063, is a type FEA(E) and was manufactured by Greenbrier in Poland in 2004/05 (figure 4). It was carrying two freight containers. At the leading end of the wagon was a 20 ft container (8’ 6” high) loaded with scrap metal and weighing 28.83 tonnes; at the trailing end was an empty 40 ft container (9’ 6” high) weighing 3.88 tonnes.

Figure 4: FEA wagon being loaded with a 40 ft container

External circumstances

18 Local weather reports for the time of the derailment record that the temperature was approximately 9°C and the conditions were dry. The relevance of the weather conditions at the time is referred to at paragraph 64.

[1] These are also known as ‘container flats’. For the purposes of this report, the term includes wagons with a central spine and outriggers, such as the FEA(E).

The sequence of events

19 The container at the leading end of wagon No. 641063 had been loaded with scrap metal at Beaver Metals' premises at Water Orton, Birmingham, on 14 October 2013. It was then moved by road to Freightliner's Lawley Street depot, where it was loaded onto wagon No. 641063 within the consist of train 4L77. Train 4L77 departed from Lawley Street shortly after 23:00 hrs the same day. Its journey via the West Coast Main Line to the point where it derailed was uneventful. It diverged onto the Up North London line just before 02:40 hrs on 15 October. As the train approached the site of the disused Primrose Hill station, the leading axle of the trailing bogie on the fifth wagon derailed to the right, while negotiating a left-hand curve. The locomotive's on-train data recorder (OTDR) indicates that the train was travelling at 17 mph (27 km/h) at the time of the derailment. The trailing axle on this bogie derailed to the right approximately 164 metres later.

20 Approximately 905 metres from the initial point of derailment, the derailed bogie encountered the *crossing* at Camden Road West Junction; at this point the train was travelling at 23 mph (37 km/h). The forces from the impact with the crossing caused the trailing bogie to come apart (figure 5) and the leading bogie on the same wagon to derail. The empty 40 ft container was dislodged from its *spigots*; it subsequently toppled from the left-hand side of the wagon and demolished an overhead line stanchion. The air pressure in the train's brake pipe was lost when it was damaged as a result of the impact with the crossing. This automatically applied the train's brakes and brought it to a stand 90 metres later.

Figure 5: Trailing bogie from wagon No. 641063 following the derailment

The investigation

Sources of evidence

21 The following sources of evidence were used:

- RAIB and Network Rail site survey data and photographs;
- weight measurements of the loaded 20 ft container;
- examination of the derailed wagon;
- data from Network Rail's *Wheelchex* system;
- data from Network Rail's track geometry measurement train;
- data from the train's on-train data recorder (OTDR);
- historic data on the loading of intermodal freight trains;
- witness statements;
- visits to container terminals and meetings with operators of FEA wagons;
- notes of freight industry meetings relating to the issue of *asymmetric loading* of freight wagons;
- specifications and *vehicle acceptance* records for FEA wagons;
- computer modelling of the derailment mechanism (carried out using VAMPIRE® vehicle dynamic modelling software);
- weather reports and observations at the site; and
- a review of previous RAIB investigations that had relevance to this accident.

Acknowledgements

22 The RAIB would like to thank ETS Consulting (http://www.ets-consulting.org), who supplied data on container loading, paragraph D4, appendix D. This was obtained using the LASSTEC load measuring system[2].

[2] http://www.conductix.com/en/product-groups/lasstec-twistlock-load-sensing-system.

Key facts and analysis

Background information

Track twist

23 *Track twist* is the variation in cant (the height of one rail relative to the other) over a given distance. Network Rail standards and processes for track inspection and maintenance call for track twist to be measured over a base distance of 3 metres; this distance has been used by different railway administrations over many years.

24 A twist fault exists when the track twist exceeds a threshold value. Network Rail specifies *intervention limits* for twist faults in its company standard NR/L2/TRK/001/mod11, 'Track geometry - Inspections and minimum actions'[3]. Depending on the severity of the twist fault, these require corrective action within seven days[4], thirty-six hours or, in extreme cases, for the line to be blocked until the fault has been corrected.

The loading of freight containers on flatbed wagons

25 Intermodal freight traffic in Britain is typically carried by road or rail between inland freight terminals and deep-sea container ports using freight containers (large metal boxes). The principal intermodal rail freight operators are Freightliner, DB Schenker, GB Railfreight and Direct Rail Services. Each company operates a variety of types of flatbed wagon, on which the containers are mounted.

26 The overall dimensions of standard containers are given in ISO (International Organization for Standardization) standard 668:1995. Containers have been carried by train in Britain since the 1960s; early types were predominantly 20 ft and 30 ft in length. More recently, 40 ft containers have replaced 30 ft containers. Early flatbed wagons were known as '60 ft' wagons and could carry appropriate combinations of the three different lengths of container.

27 Different versions of the FEA wagon have been built by Marcroft Engineering, Greenbrier and Astra Rail since 2003. Greenbrier has supplied permanently coupled pairs of FEA(B) as well as single FEA(D), FEA(E) and FEA(S) flatbed wagons. These are all 60 ft wagons and are equipped with spigots that enable combinations of containers of various lengths to be carried; the spigots retain the containers in place on the wagon deck and are mounted on retractable hinged plates.

28 In order to maximise wagon loading, 40 ft containers are generally carried on one end of a wagon with a 20 ft container on the other end. Freightliner has provided data on the weight distributions of 20 ft and 40 ft containers carried on train 4L77 over a twenty-four week period from October 2013 to April 2014 (figure 6; see also figure D1, appendix D). Approximately one third of 20 ft containers weighed more than 24 tonnes (gross). Heavy 20 ft containers typically carry scrap for export.

---

[3] Network Rail's standard NR/L2/TRK/001 'Inspection and Maintenance of Permanent Way' includes nineteen modules; these are referred to in this report as NR/L2/TRK/001/modxx, where xx is the reference number of the module concerned. The version of the standard, and each of the modules, that was current at 15 October 2013 was issue 6; this was effective from 2 February 2013.

[4] For a curve with radius less than 400 metres, such as existed at the point of derailment.

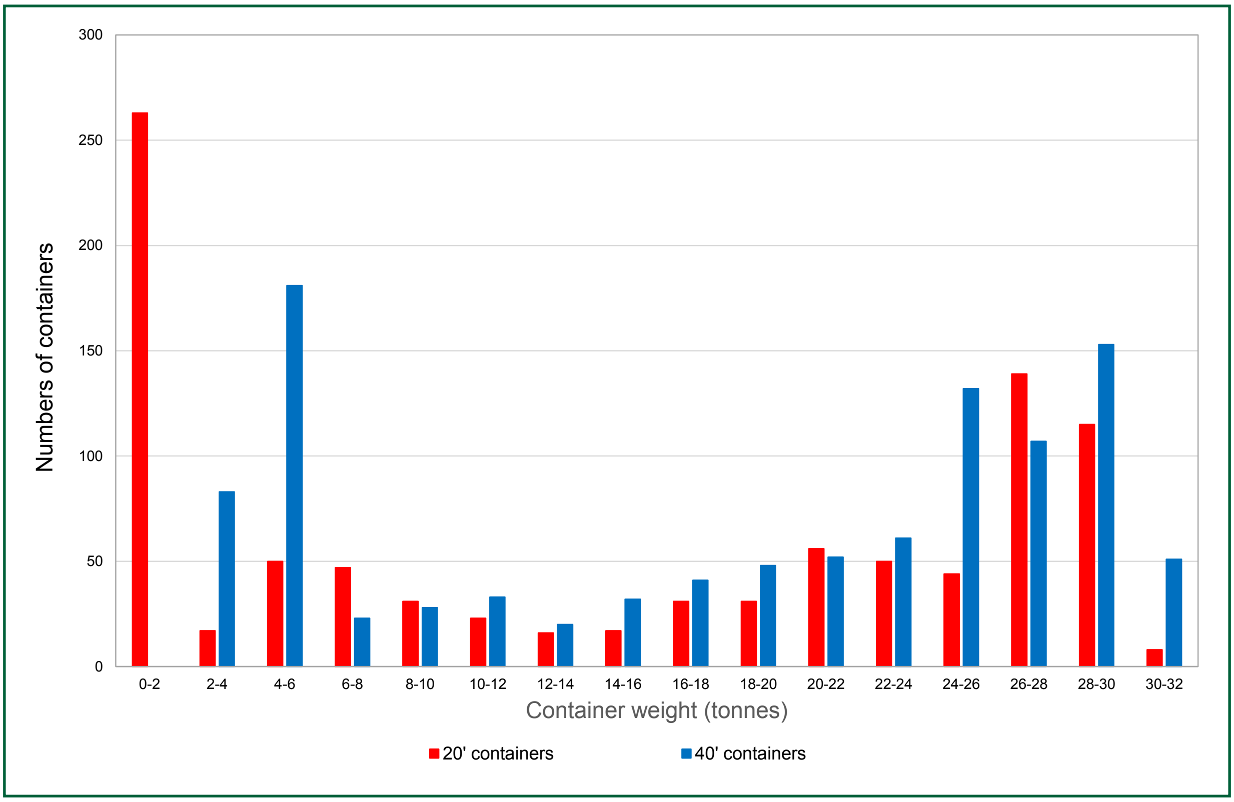


Figure 6: Container weight distributions - train 4L77 (24 weeks October 2013 - April 2014)

29 Appendix D contains guidelines for container packers[5] on the distribution of loads within containers. The most definitive guidance is provided in the 'IMO/ILO/UN ECE Guidelines for Packing of Cargo Transport Units' published by the International Maritime Organization (see paragraph D3(a), appendix D). This includes the requirement that no more than 60% of the load should be concentrated in less than half of the length of a container; International Standard ISO 3874 equates this to 5% *eccentricity* (paragraph D3(c), appendix D). For a 20 ft container, this is equivalent to an offset in the *centre of gravity* of the load of 303 mm longitudinally or 122 mm when applied laterally (paragraph D3(d), appendix D). In practice, it is difficult for a carrier to measure if a load in a container is asymmetric, as most existing container-handling equipment is not capable of detecting offset loads. In addition, movement of the load may subsequently occur in transit if it has not been properly secured; the IMO guidelines emphasise the importance of securing the cargoes within containers.

30 Freightliner specifies its maximum permissible wagon loadings in 'Management Instruction, Engineering – Permissible Loading of Freightliner Intermodal Wagons', Ref. MIE 0767. This document details the various combinations of container types and weights that can be carried on each type of wagon to remain within axle weight limits; it permits the longitudinal loading of wagons to be asymmetrical.

[5] Containers may be packed by a wide range of organisations, including those which have no direct connection with the railway industry.

31 The version of MIE 0767 current at the time of the derailment at Primrose Hill contains tables correlating the maximum permissible weights of 40 ft containers and 20 ft containers carried on FEA(B)[6] and FEA(E) wagons (see appendix G). These maximum weights are inversely related in order to keep the axle weights within limits prescribed for operation at speeds up to 75 mph (121 km/h). For an FEA(E) wagon carrying a 20 ft container weighing the maximum permitted 30 tonnes, MIE 0767 permits the wagon also to be loaded with a 40 ft container weighing anything between its empty weight (typically 3.64 tonnes) and 9.32 tonnes[7]. These weights correspond to a maximum *longitudinal weight ratio*[8] of 2.70 : 1.

32 In comparison, the version of MIE 0767 that was current at the time of an earlier derailment of an FEA wagon, in 2007 (see paragraph 123), permitted an FEA(B) wagon carrying a 20 ft container weighing a maximum of 24 tonnes also to carry a 40 ft container weighing between its empty weight and 35 tonnes. These load configurations correspond to a maximum longitudinal weight ratio of 2.37 : 1.

33 After a 60 ft flatbed wagon such as the FEA has been loaded with a 40 ft container, the operator requires as much flexibility as possible when subsequently loading a 20 ft container onto the same wagon. Due to the spread of container weights, this can result in combinations of heavy 20 ft and light 40 ft containers being carried (see paragraph 73).

Criteria for acceptance of rail vehicles with respect to resistance to derailment

34 The process by which FEA wagons were confirmed to have an acceptable resistance to derailment was defined in *Railway Group Standard* 'Resistance of Railway Vehicles to Derailment and Roll-Over', GM/RT2141. The stated purpose of GM/RT2141 Issue 2, which was current at the time, was 'to define the minimum requirements which must be met by railway vehicles … in order that they have acceptable resistance to flange-climbing derailment …' The standard contains alternative routes to acceptance, shown in figure 7. The simplest route involves static measurements of *wheel unloading* and the rotational stiffness of a vehicle's bogies; these tests are defined in Appendices A and B of GM/RT2141. If these tests are passed, confirmation that the vertical and lateral accelerations of the vehicle body do not exceed defined limits is required from dynamic testing; this is defined at Appendix D of GM/RT2141, and should be carried out on representative track at speeds up to and including the vehicle's maximum speed.

35 Issue 2 of GM/RT2141 required 'all significant representative conditions' to be assessed; it did not specify what load conditions should be included[9]. Acceptance of FEA wagons against the standard is discussed at paragraphs 100 to 105.

---

[6] The FEA(B) wagon differs from the FEA(E), the type that derailed at Primrose Hill on 15 October 2013, in that it is a twin wagon with the two halves permanently coupled together whereas the FEA(E) is a single wagon. This results in some insignificant differences (as far as this investigation is concerned) in the overall weight and the longitudinal weight distribution.

[7] MIE 0767 includes the general provision that 'Consideration should be given to balanced loading where possible, whilst not exceeding maximum axle loading.' This means that a single 20 ft container on a flatbed wagon would normally be carried in the centre position.

[8] Load on the axles of the heavier bogie : load on the axles of the lighter bogie.

[9] Issue 3 of GM/RT2141 now states 'The range of vehicle test conditions shall take account of the effect of … vehicle weight distribution (for example tare [ie empty], laden, partially laden) [and the] range and effect of possible in-service loading configurations (for example distribution of containers, stiffness effect of the load).'

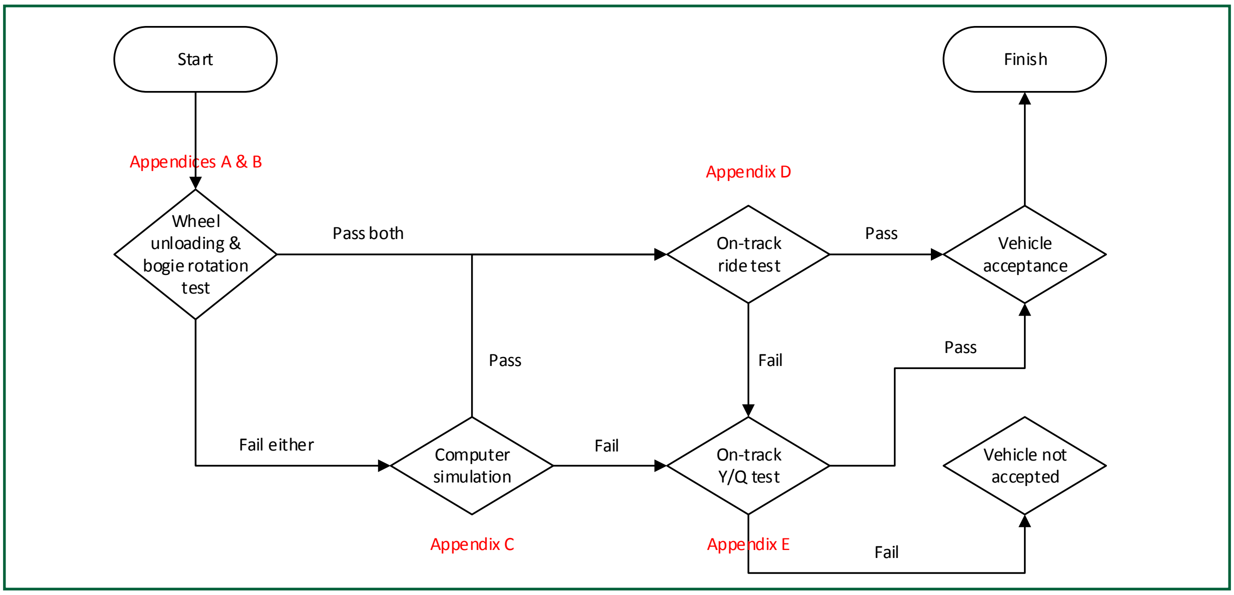


Figure 7: Flowchart showing alternative routes to acceptance contained within GM/RT2141 (also showing appendices of the standard where processes are defined)

36 Although not applicable at the time FEA wagons were accepted, the *Technical Specification for Interoperability* for the 'Rolling stock – Wagons subsystem' (Commission Regulation (EU) 321/2013 of 13 March 2013 refers[10]) requires the resistance to derailment of new freight wagons to be assessed against the requirements of British Standard 'Railway applications – Testing for the acceptance of running characteristics of railway vehicles – Testing of running behaviour and stationary tests', BS EN14363:2005. There is some overlap between the requirements in BS EN14363 and those in GM/RT2141, including the 'static or quasi-static measurement of wheel unloading on twisted track' defined at Appendix A of the standard. RSSB is considering making changes to GM/RT2141 to align it with BS EN14363; it has advised the RAIB that no changes would be required to the Appendix A test.

Twist faults and vehicle resistance to derailment

37 RSSB's report 'Cost-effective reduction of derailment risk', Ref. T357, January 2006, considered whether changes to Railway Group Standards could be effective in managing the risk associated with derailments that appeared to have been caused by track or vehicle factors, and in which both the track and the vehicle were compliant with existing standards. The report found that significant impact on reducing such derailments could be made by early identification and rectification of poor track geometry, and by successfully addressing poor vehicle loading. With respect to low-speed derailments on twisted track, it concluded:

a. There was a wide variety of additional contributory factors, although poor loading [of particular vehicle types] and high installed cant on low speed curves often featured.

b. Control of these derailments would be improved by earlier twist identification and better management of known derailment risks.

[10] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02013R0321-20140101&from=EN

38 Appendix C of Railway Group Standard 'Track System Requirements', GC/RT5021, refers to a perceived incompatibility between the track twist limits and vehicle resistance to derailment requirements contained in GC/RT5021 and GM/RT2141 respectively. It concluded that there was no evidence that the two standards were incompatible; it also stated that RSSB's report Ref. T357 had identified no evidence of incompatibility between the standards.

Identification of the immediate cause[11]

39 **The leading right-hand wheel of the trailing bogie on wagon No. 641063 derailed after its flange climbed up and over the rail.**

40 There is a probability of derailment by *flange-climb* when the ratio of the lateral force of the wheel flange on the rail (Y) to the vertical wheel load (Q), known as the *Y/Q derailment quotient*, exceeds a critical limit value. This means that a reduction of load on a wheel (Q) will tend to increase the likelihood that lateral forces (Y) will cause the wheel flange to climb the rail. The critical limit value of Y/Q is dependent on both the level of friction and the angle of contact between the wheel flange and the rail head. The higher the friction, or the lower the contact angle, the lower the critical limit and therefore the greater the risk of derailment. The investigation has found that the derailment was caused by flange-climbing of the leading right-hand wheel of the trailing bogie.

41 The RAIB examined the damage to the track between the point of derailment and the stopping position of the train, as well as the damage to the wagon; this was consistent with the wagon having run with the trailing bogie derailed until it reached the crossing at Camden Road West Junction (paragraph 20). The RAIB also reviewed information on the wagon loading and Network Rail's data on the track geometry, and concluded that wagon No. 641063 had probably derailed as a result of wheel unloading on twisted track.

42 The RAIB found no evidence that any other effects, such as a suspension defect or the way the train was being driven (see paragraph 117), contributed to the wheel flange-climbing over the rail head and into derailment.

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

Identification of causal factors[12]

43 Using track geometry data it had collected at the site of the derailment, and the known characteristics of the wagon, the RAIB commissioned dynamic analysis of the derailment on 15 October 2013 using VAMPIRE® software[13]. The results support the conclusion that the accident occurred due to flange-climb resulting from a combination of the following factors:

a. the track geometry and condition (paragraphs 46 to 70);

b. the combination of longitudinal and lateral asymmetric loading of the wagon, possibly exacerbated by the characteristics of the type of wagon involved (paragraphs 71 to 99).

These factors are now considered in turn.

The track geometry and condition

44 The following factors associated with the track geometry and condition were causal to the derailment:

- there were opposing *twist faults* (incidences of excessive track twist) present (paragraphs 46 to 57);
- the curve was not fitted with a *check rail* (paragraphs 58 to 61); and
- the level of friction between wheel and rail was relatively high (paragraphs 62 to 67).

45 It was also concluded that lateral *track irregularities* (paragraphs 68 to 70) increased the probability of derailment.

The presence of twist faults

46 The track had opposing twist faults which significantly reduced the load on the first wheel to derail.

47 Network Rail routinely makes recordings using its track geometry measurement train, known as the track recording vehicle (TRV), in order to find track defects such as twist faults. Measurements of track twist were made by the TRV on 23 November 2012 and 22 November 2013 (after the derailment). The TRV twist measurements are plotted at figure 8 together with the results of the RAIB's survey after the accident on 15 October 2013[14].

---

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

[13] This analysis used a validated model of the FEA(E) wagon, track data compiled from surveys by the RAIB and Network Rail, and the weights of the containers carried on wagon 641063.

[14] This incorporates data on track voids which were measured when a locomotive passed over the track at the point of derailment.

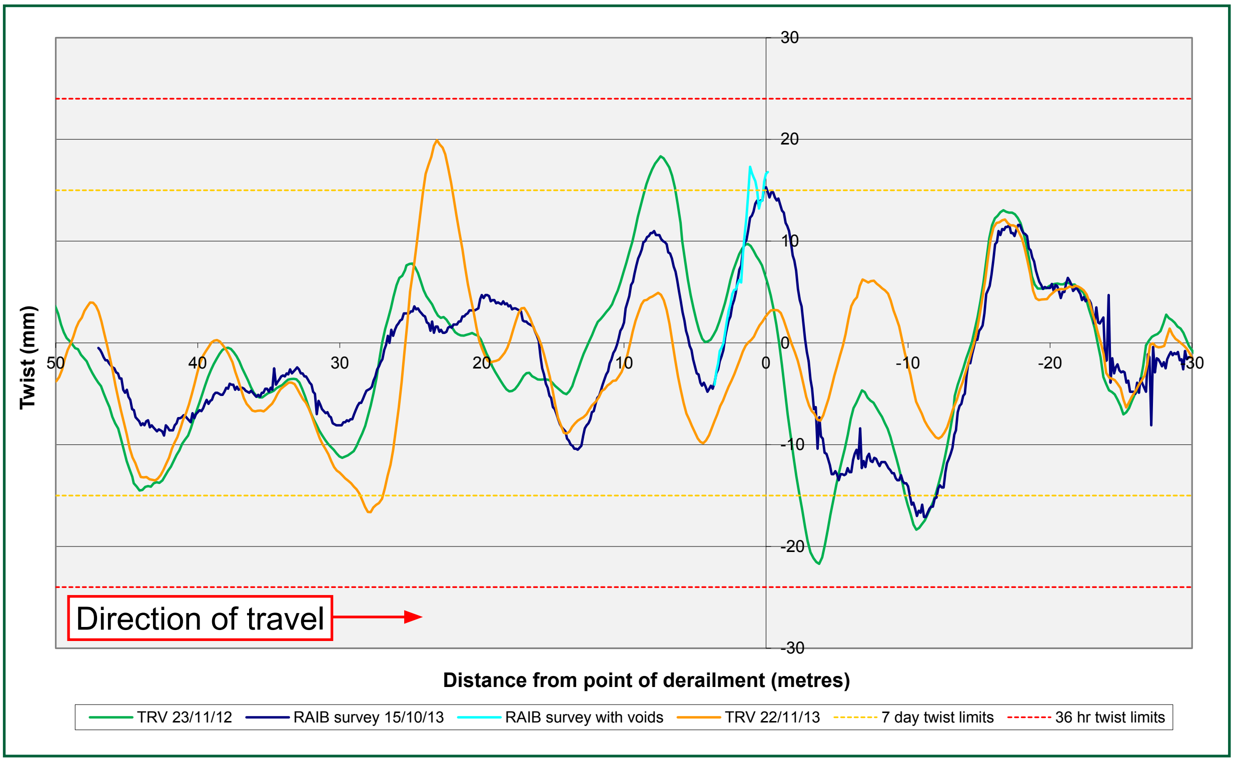


Figure 8: 3 metre twist

48 Although Network Rail specifies and measures track twist over 3 metres (paragraph 23), the axles in each bogie of an FEA(E) wagon have a wheelbase of 2 metres while the bogie centres are approximately 14 metres apart. The track twists over these distances interact with the wagon's suspension to determine the transfer of loads between the individual wheels, and are shown at figure 9. The effect of the 14 metre twist measured at the point of derailment was to reduce the load on the right-hand wheels of the trailing bogie of wagon No. 641063 relative to the left-hand side. This was compounded by the effect of the 2 metre twist, which was to reduce the load on the right-hand wheel of the leading axle (of each bogie) relative to that on the trailing axle. The load on the first wheel to derail was therefore reduced by the combination of the 14 metre and 2 metre twists. The VAMPIRE® dynamic modelling showed that a reduction in the track twist to 75% of its measured values would not have resulted in a derailment for any of the vehicle loading configurations modelled (see paragraph 85), with the exception of one case modelling the most asymmetric configuration.

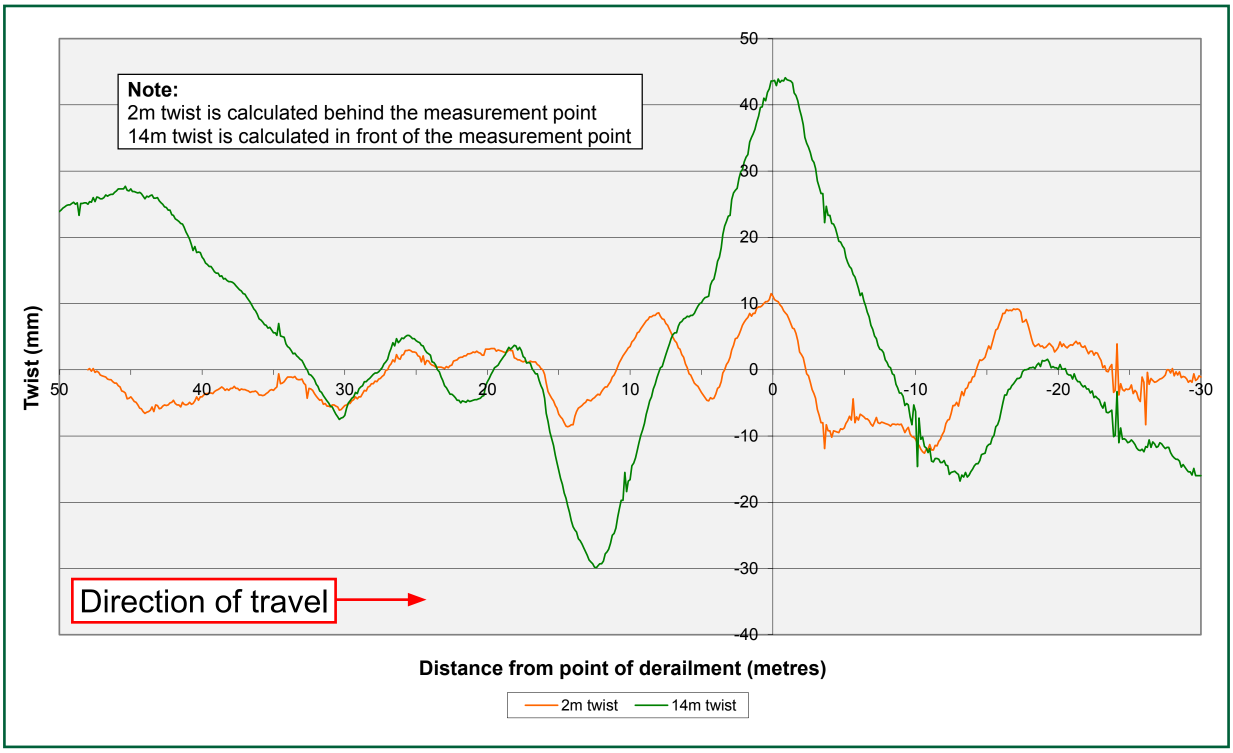


Figure 9: Track twists measured over 2 and 14 metres

49 Figure 8 shows that the TRV run on 23 November 2012 recorded three different 3 metre twist faults within 11 metres of the point of derailment that exceeded the threshold at which corrective action was required within seven days (the 'seven day intervention limit')[15]. They were therefore faults that Network Rail allows to exist for a limited number of days, over which trains could pass without restriction. Track maintenance staff subsequently *lifted and packed* the track to correct these twist faults on 26 November 2012; this is normally an appropriate remedial action for such defects. However, two twist faults were again present over the same distance by the date of the derailment, 15 October 2013, despite further remedial action on 4 October 2013 (see paragraph 56)[16].

50 The TRV did not run over the Up North London line for 46 weeks before the derailment and track maintenance staff were unaware of specific geometry faults that had developed over this period. They were however aware of the generally poor condition of the track (see paragraph 54).

51 The frequency with which the track geometry measurement train should run over individual lines depends on the category of track, as defined in standard NR/L2/TRK/001/mod11. The track categorisation is based on the speed of traffic and equivalent annual tonnage using that line. The portion of the Up North London line within LNW(S) is category 3 track, while the portion of the line that lies within Network Rail's Anglia Route had been reclassified as category 4 following renewal of the track in 2009.

[15] NR/L2/TRK/001/mod11 states that if multiple faults exist, the necessary corrective action(s) should be completed to a shorter timescale.

[16] The RAIB found no evidence to indicate that these twist faults would have occurred as a consequence of the derailment.

52 The nominal planning interval for geometry recording for category 3 track is 16-weekly (with a maximum interval of 36 weeks), whereas it is 24-weekly for category 4 track; these frequencies have been unchanged since issue 4 of NR/L2/TRK/001. Before this version of the standard, which was effective from 5 December 2009, the required geometry recording frequency was 12-monthly for track of both categories 3 and 4 (with a maximum interval of 14 months). At the time of the derailment on 15 October 2013, the TRV was planned to run at 24-weekly intervals over the North London lines, consistent with the category 4 classification on the Anglia side of the Route boundary. The RAIB has been unable to determine why the more onerous inspection frequency required for the LNW(S) portion of the line, classified as track category 3, did not take precedence. The scheduling of TRV runs for the whole of LNW(S) is carried out centrally, although the individual Infrastructure Maintenance Engineers for each Maintenance Delivery Unit (MDU) are ultimately responsible for their sections of route.

53 Following the run by the TRV over the Up North London line on 23 November 2012, it was next scheduled to run in May 2013. However, this run did not take place as planned. It is not unusual for the train to be diverted for operational reasons or for its route to be subject to reprioritisation at short notice. In such circumstances, NR/L2/TRK/001/mod11 requires the track maintenance engineer (TME) for the area to consider whether measurement is needed before the next scheduled recording, although no criteria are given to assist the TME. The RAIB has not seen any evidence that any action was taken to obtain additional geometry measurements between May and October 2013.

54 For plain line jointed track of category 3, a basic visual inspection[17] should be carried out weekly and the *section manager*'s inspection every 13 weeks. The basic visual inspection reports for the weeks leading up to the derailment on 15 October 2013 did not identify any specific defects that were relevant to the derailment. The more general reports detailing the findings from the three section manager's inspections before the derailment stated:

a. 'Track in exceptionally poor condition following heavy maintenance. *Wetbeds* continue to expand.' (30 May 2013).

b. 'It is difficult to express on paper how poor & deteriorating this entire patrol[18] is.' (2 August 2013; this was countersigned by the TME on 11 October 2013, four days before the derailment).

c. 'Entire patrol in very poor condition.' (26 September 2013).

[17] The purpose of basic visual inspections is described in NR/L2/TRK/001 as being to 'identify any immediate or short term actions required. These are generally faults that require action within four weeks'.

[18] 'Patrol' here refers to the entire section of the Up and Down North London lines within LNW(S), paragraph 10. These comments do not indicate that the track in the immediate vicinity of the point of derailment was any worse than the rest of the LNW(S) portion of the North London lines.

55 There were known underlying drainage problems with sections of the track on the Up North London line, although these did not include the track in the immediate vicinity of the point of derailment. Remedial work had taken place in February 2013 to clear blocked drains. A proposed renewal of the drainage had been discussed following a joint site visit by the TME and Route Asset Manager (Track) on 14 June 2013 for possible delivery within Control Period 4 (April 2009 to March 2014), subject to the availability of access and resources. There had been insufficient time to deliver this within Control Period 4, so it had been planned for completion in Control Period 5 (April 2014 to March 2019).

56 Following the joint site visit with the TME in June 2013, the Route Asset Manager (Track) requested the TME to arrange regular lifting and packing on the section of track with poor vertical alignment, although the limits of this were not defined. Maintenance records show a 'lift and MSP' (*measured shovel packing*) was completed on 4 October 2013 for a section of the Up North London line, including the point of derailment, 286 yards (261 metres) long.

57 Network Rail advised that, following the derailment, work was carried out to dig out the poor formation and approximately six tonnes of new ballast was installed to improve the track alignment.

The absence of lateral restraint

58 **There was no check rail on the tight radius curve to provide lateral restraint to the wheels of the wagon and prevent flange-climbing as it negotiated the curve.**

59 The RAIB's report 'Locomotive derailment at Ordsall Lane Junction, Salford, 23 January 2013' (report 07/2014), identified that Railway Group Standards do not completely control the risk of derailment as the separate standards for vehicles and track do not consider the worst possible combination of conditions. This risk is mitigated by check rails and, although Network Rail states it is not their primary purpose, by trackside rail lubricators (see paragraph 65).

60 The point of derailment was on a curve of approximately 187 metres radius; this did not have a check rail, which would have prevented the derailment. Railway Group Standard GC/RT5021, 'Track system requirements', and Network Rail standard NR/L2/TRK/2102, 'Design and construction of track', both require curves on passenger lines with radii of less than 200 metres to have check rails. Network Rail has been unable to find a record of the radius of the curve at the location of the derailment and has advised that there is no record that this curve had ever had a check rail installed. In addition, the TME incorrectly believed this was a freight-only line (paragraph 10), which therefore would not have required fitment of a check rail.

61 Recommendation 1 of the RAIB's report into the derailment at Ordsall Lane Junction is for Network Rail to identify curves that are non-compliant with Railway Group Standard GC/RT5021 and Network Rail standard NR/L2/TRK/2102, and to implement measures to mitigate the risk of derailment (see paragraph 134b).

The interface between wheel and rail

62 **The level of friction between wheel and rail may have increased the probability of derailment. This is a possible causal factor.**

63 RAIB photographs, taken close to the point of derailment on 15 October 2013, reveal a band of wear along the *gauge corner* of the rail, as well as the presence of metal particles (figure 10); this is indicative of a relatively high level of friction. The results of the VAMPIRE® dynamic modelling of the derailment on 15 October 2013 demonstrate that the *coefficient of friction* (μ) between the wagon wheels and the rail was relevant to the probability of derailment (see paragraph 86a).

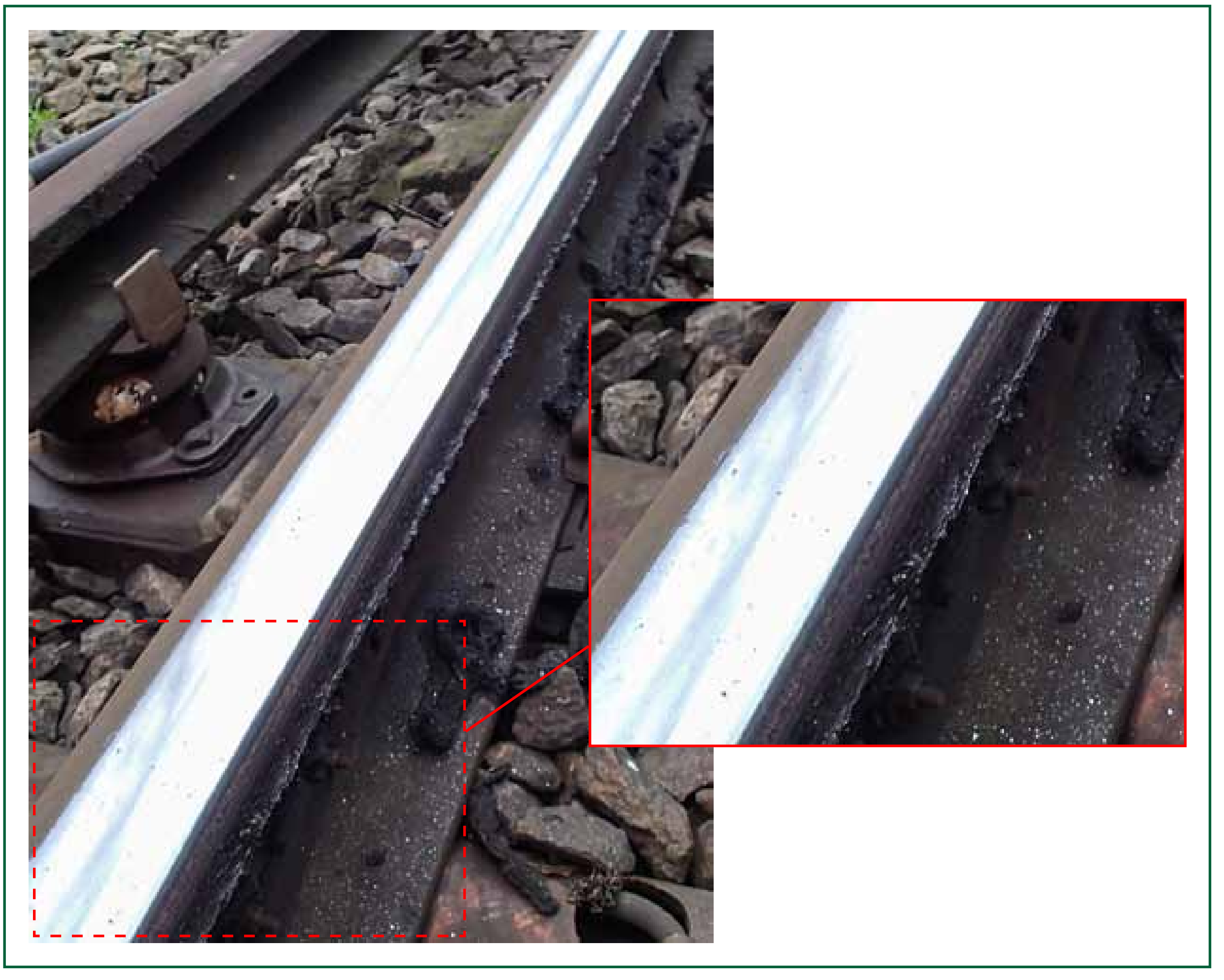


Figure 10: Rail head close to the point of derailment

64 Atmospheric moisture can reduce the coefficient of friction at the wheel/rail interface. However, the weather was dry at the time of the derailment (paragraph 18). Had moisture been present in the form of dew or rain, this would have reduced the level of friction, possibly preventing the derailment.

65 Network Rail uses rail lubricators to apply lubricant to the *gauge face* on curves by applying grease to the flanges of passing wheels. Network Rail company standard NR/L2/TRK/8006, 'Installation and management of rail mounted lubricators', stated that one of the reasons for installing a lubricator was to reduce the risk of potential derailment. However, this standard was superseded in 2011 by NR/L3/TRK/3510/A01, 'Lubrication of Plain Line Running Rails, Check Rails and S&C', which no longer refers to derailment. This issue has previously been discussed in the RAIB's report into the derailment at Ordsall Lane Junction on 23 January 2013 (paragraph 59), which identified that Network Rail continues to emphasise that the primary purpose of rail lubrication is infrastructure asset protection (for instance to reduce rail wear) rather than the mitigation of derailment.

66 A lubricator is installed approximately 75 metres before the point of derailment. Network Rail's track engineering form NR/L3/TRK/TEF3219, which covers site specific assessment of lubrication equipment, indicates this is sufficiently close that grease should have been carried along the rail head at least as far as the point of derailment. Inspection records from 21 August 2013 and 24 October 2013 (nine days after the derailment) show that maintenance staff considered the lubricator was working correctly. Although figure 10 reveals a band of grease along the gauge face of the rail, the evidence of wear (paragraph 63) indicates that the coefficient of friction was relatively high in the wheel-rail contact area.

67 A subsequent examination by the RAIB on 20 May 2014, during which the presence of grease was confirmed in the contact area on the gauge corner of the rail at the point of derailment, found a significant increase in the amount of grease being delivered from the lubricator (figure 11). This difference indicates the lubricator may not have been working effectively at the time of the derailment. However, Network Rail advised that no adjustment had been made to the lubricator during the intervening period.

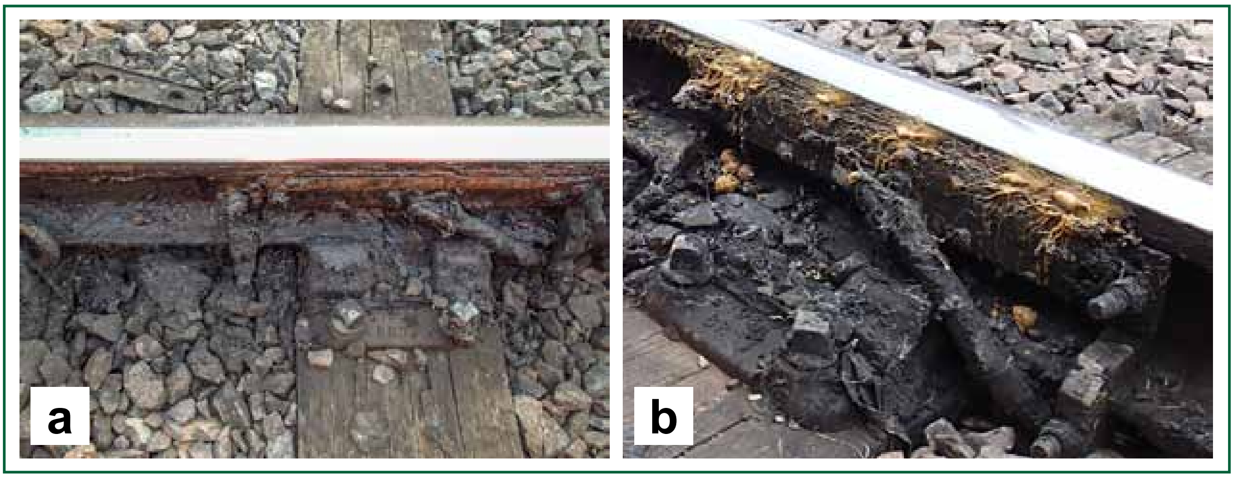


Figure 11: The grease distribution unit at the lubricator
(a) following the derailment on 15 October 2013 and (b) showing fresh grease on 20 May 2014

The track alignment

68 Lateral track irregularities increased the probability of derailment by increasing the lateral forces at the wheel/rail interface.

69 In order to carry out the VAMPIRE® dynamic modelling, a mathematical approximation of the curve in the vicinity of the derailment was created; this was based on survey data measured after the accident on 15 October 2013. The deviations between the survey data and the approximation of the curve, such as may exist at rail joints and other track features, were captured as a separate set of lateral 'irregularity' data. The modelling was carried out using the surveyed location of the track by re-combining the mathematical approximation of the curve with the irregularity data.

70 Network Rail specifies and measures lateral alignment over 35 metres and 70 metres. An alignment fault at the fourteen day intervention limit was recorded 46 metres on the approach to the point of derailment when the TRV ran on 22 November 2013. At this distance, the alignment fault was sufficiently remote not to have affected the derailment of wagon no. 641063. Further VAMPIRE® simulations were carried out to establish the sensitivity of the modelling results to lateral irregularities over shorter distances than those measured by Network Rail. The irregularity data described at paragraph 69 were scaled to 75% of their original values (ie reducing the deviations from the approximated curve). The results for most of the vehicle loading configurations modelled (see paragraph 85) showed no significant difference; however, the reduction in lateral irregularities was sufficient to change the result for the 'base case' vehicle configuration from a (marginally) predicted derailment to no predicted derailment.

The wagon and the way it was loaded

The distribution of the load on wagon No. 641063

71 The centre of gravity of wagon No. 641063 was offset from its centre both longitudinally and laterally. The longitudinal asymmetry was principally the result of the positioning and weights of the containers on the wagon, with a secondary contribution from a longitudinal offset in the centre of gravity of the 20 ft container on the front of the wagon. The lateral asymmetry was the result of the lateral offset in the centre of gravity of the same 20 ft container.

72 The 20 ft container was loaded with scrap electrical machines and had a gross weight of 28.83 tonnes; the empty 40 ft container on the rear of the wagon weighed 3.88 tonnes. Consequently, the load on the axles of the leading bogie of wagon No. 641063 was an estimated 2.7 times the load on the axles of the trailing bogie (a longitudinal weight ratio of 2.7 : 1)[19]. This longitudinal weight ratio was just within the most extreme asymmetry that was permitted by Freightliner's loading standard MIE 0767 (paragraph 31).

73 Data on the weight distribution of containers handled at a British port over a two year period (see paragraph D4, appendix D) indicates that, if no attempt was made to balance the loads on container wagons longitudinally[20], approximately 5% of random combinations of 20 ft and 40 ft containers complying with the current MIE 0767 loading criteria for FEA wagons would result in longitudinal weight ratios equal to or greater than 2.4 : 1[21].

---

[19] This allows for the offset in the centre of gravity of the 20 ft container towards the front of the wagon by an estimated 200 - 250 mm (see paragraph 76).

[20] Freightliner's guidance to staff involved in loading wagons states that the weights of two containers carried on the same wagon should be balanced as far as possible, although its software-based load management system does not reflect this guidance (see paragraphs E5 and E6, appendix E).

[21] A longitudinal ratio of 2.4 : 1 is the maximum that would have been possible for a wagon loaded in accordance with the loading rules in MIE 0767 at the time of the derailment at Duddeston Junction on 10 August 2007.

74 The RAIB calculated the lateral offset of the centre of gravity of wagon No. 641063 using data from Network Rail's wheel impact load measurement system, Wheelchex[22]. Unfortunately, train 4L77 had run past only one Wheelchex site before the derailment occurred; this was at Cheddington, and the system had partially failed so that it was recording data for only the right-hand side of the train. The Wheelchex data for the train's locomotive, number 70007, proved to be inconsistent with its previously recorded weight (allowing for differences in fuel load). In order to verify the Wheelchex data, the RAIB fitted *normal distributions* to the variations in the recorded right-hand side wheel weights[23] for forty-one freight locomotives passing Cheddington twenty-four hours before and after train 4L77. This confirmed that the weights recorded for locomotive 70007 were within 95% confidence limits for the variations from average. Applying the same 95% confidence limits to the weights recorded for wagon No. 641063 provided a range of values for the *lateral weight ratio* of the wagon before the derailment.

75 The RAIB also arranged for measurements to be made of the weight distribution of the load within the 20 ft container, to enable calculations of the lateral asymmetry of the wagon at the time of the derailment. No evidence was found that the contents of the container had been secured as per the IMO guidelines (see paragraph D3(c), appendix D), although Beaver Metals has advised that it had been loaded in such a way that there were no voids in the container that would allow for any movement of the load unless the container was subjected to violent and extreme force. Various configurations of the loaded container were measured:

a. The weight at each corner of the container was first measured when it was recovered from the accident site at Camden Road West Junction. However, confidence in the values obtained was limited because of the possible disturbance to the load arising both from the derailment itself and from the recovery operation.

b. Further measurements were made by the RAIB on 27 November 2013 after the container had been returned to its point of origin, Beaver Metals' premises at Water Orton.

c. The contents of the container were then repacked in an attempt to replicate the original weight distribution of the load (figure 12). This exercise was aided by photographs taken by Beaver Metals while the container was being loaded on 14 October 2013 (these are not shown because there is no equivalent photograph of the fully-loaded container; this also means there is no certainty about the final configuration of the load when the container left Beaver Metals).

d. Witness marks observed during repacking of the container indicated that the largest item of scrap, weighing 12.80 tonnes, had been in contact with the walls of the container at some stage, probably during the derailment. Since it was not possible to replace it in the same position following repacking, the measurements made were not representative of the original weight distribution and the RAIB has estimated what this might have been.

---

[22] Although this system is intended primarily to measure impact loads, it also provides data on wheel weights.

[23] The recorded wheel weights were compared with the average wheel weights for each class of locomotive.

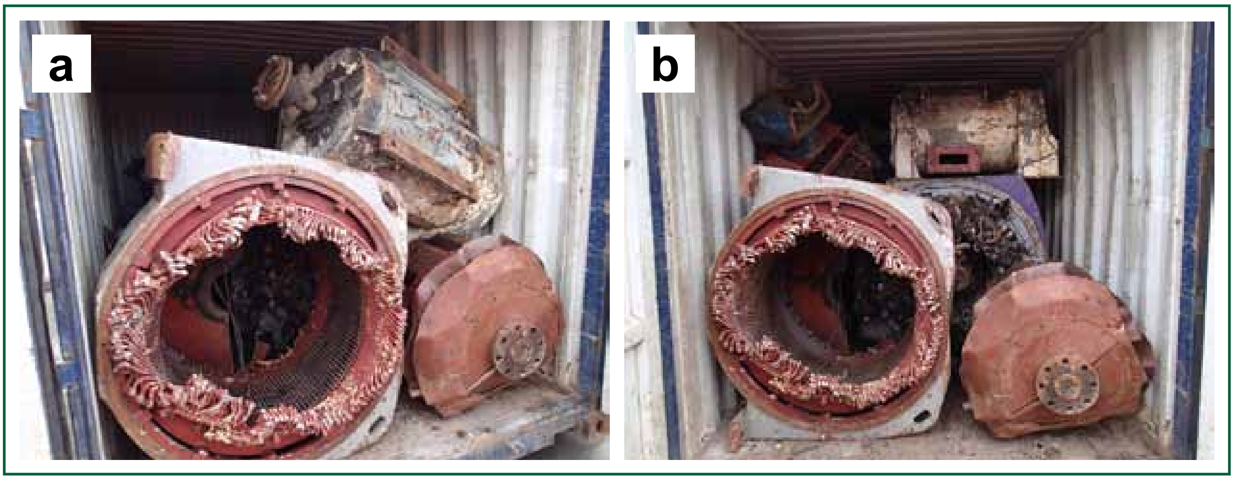


Figure 12: Contents of the 20 ft container on 27 November 2013
(a) before repacking and (b) after repacking to replicate the original weight distribution

76 Based on the measurements of the 20 ft container, the RAIB estimates that the centre of gravity of the container was offset towards the left of the wagon by 100 - 240 mm (lateral eccentricity of 4 - 10%) and towards the front by an estimated 200 - 250 mm (longitudinal eccentricity of 3 - 4%) (see also paragraph 85 and figure 14).

77 The measurements of the loaded container have enabled calculations of the probable range of lateral asymmetry in the centre of gravity of wagon No. 641063. This closely overlapped the range derived from the Wheelchex data (paragraph 74).

78 UK freight operators currently have no effective means of measuring or controlling asymmetric loads in the containers they receive for carriage. The lateral eccentricity for nearly 50,000 20 ft containers weighing more than 25 tonnes that were handled at one (unspecified) British port over a two year period is shown at table 1. This indicates that the lateral eccentricity of the 20 ft container involved in the derailment at Primrose Hill was likely to have been in the most eccentric 2% of the population.

Eccentricity	> 5%	> 10%	> 15%	> 20%
Percentage of containers	1.91%	0.54%	0.34%	0.26%

Table 1: Lateral eccentricity for 20 ft containers weighing more than 25 tonnes (source: ETS Consulting)

79 In summary, the load on the left-hand wheels of wagon No. 641063 is estimated to have been between 1.2 and 1.4 times the load on the right-hand wheels (a lateral weight ratio of between 1.2 : 1 and 1.4 : 1). For reference, an FEA wagon carrying a 20 ft container weighing 30 tonnes, with a lateral eccentricity of 5% (the maximum consistent with the IMO guidelines, see paragraphs D3(a) and D3(c), appendix D), and an empty 40 ft container would have a lateral weight ratio of 1.2 : 1.

Contribution of the wagon and its load to the derailment

80 **A causal factor in the derailment was the combination of longitudinal and lateral asymmetric loading of the wagon.**

81 The following factors were linked to the above:

a. the extent of asymmetric loading of the wagon, which reduced the load on the right-hand rear wheels (paragraphs 82 to 86);

b. the rules on the loading of FEA wagons had been relaxed following the derailment at Duddeston Junction in 2007, allowing greater longitudinal asymmetry (paragraphs 87 to 94); and

it was also concluded that there is a possibility that the FEA wagon is particularly prone to flange-climbing on twisted track when loaded asymmetrically (paragraphs 95 to 99).

The effect of the asymmetric loading on wagon No. 641063

82 **Wagon No. 641063 was prone to derailment due to the extent of asymmetric loading of the wagon, which reduced the load on the right-hand rear wheels.**

83 The Union Internationale des Chemins de Fer (UIC) has published guidelines[24] on asymmetric loading:

Axle/bogie- and wheel-loads

- *Ratio between the wheel loads of a same axle in transverse direction: max. 1.25: 1 (= load should be no more than 10 cm* [100 mm] *off centre)*
- *Ratio of … bogie load in longitudinal direction … max. 3:1*

84 The University of Huddersfield analysed the weight distribution of nearly 19,000 intermodal freight wagons in the UK as part of the European 'D-Rail' research project[25]. This was carried out using uncalibrated data from the *GOTCHA* system, which is being installed by Network Rail as a replacement for Wheelchex. The results indicate that 99.9% of vehicles had a longitudinal weight ratio that fell within the UIC guideline of 3 : 1 (figure 13) and 99.7% of vehicles had a lateral weight ratio equal to or less than 1.25 : 1[26]. The results also show that asymmetrical loading tended to be either longitudinal or lateral, with few vehicles having extreme asymmetry along both axes.

[24] 'UIC-Loading Guidelines – Section 2 – Goods' (published by the Union Internationale des Chemins de Fer, available from www.uic.org/etf). The UIC guidelines refer to the lateral weight ratio for an axle. There is no direct conversion between this and an equivalent mean ratio for the wagon, as the relationship is specific to the geometry and loading of the vehicle. The maximum lateral weight ratio for the axle with the most asymmetry will be higher than the mean axle ratio, and it is important to be clear which ratio is being considered.

[25] 'Development of the Future Rail Freight System to Reduce the Occurrences and Impact of Derailment', www.d-rail-project.eu. The data presented has been filtered to exclude measurements exhibiting a high dynamic force. Further work has been proposed to calibrate the filtering process using static measurements of wheel load; this has not yet been carried out.

[26] Figure 13 includes a red limit line for a lateral wagon weight ratio of 1.25 : 1. In accordance with the UIC guideline, this limit is normally applied to the most unbalanced axle on a wagon but is used here for comparison with the mean axle load.

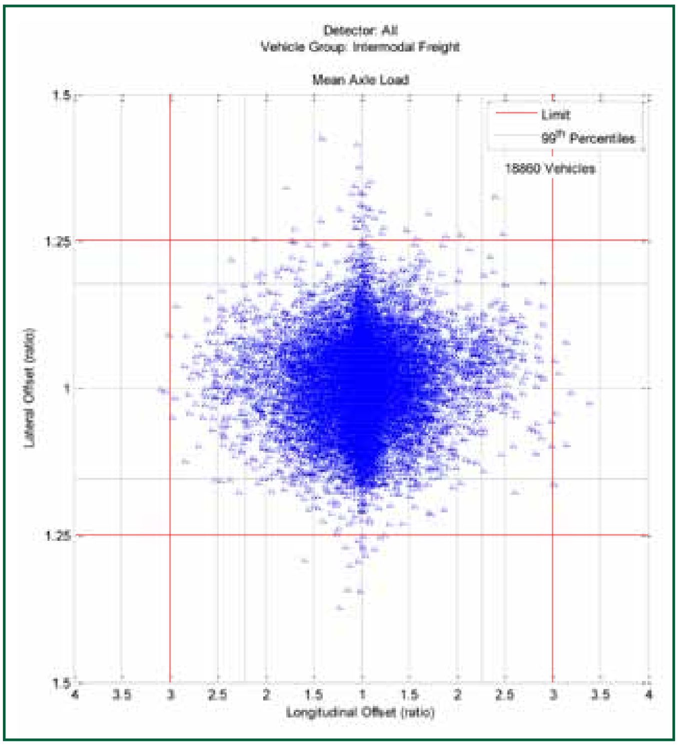


Figure 13: Weight distributions of intermodal freight wagons (courtesy University of Huddersfield)

85 The VAMPIRE® dynamic modelling (paragraph 43), was carried out with a number of different load configurations for the FEA wagon (figure 14). These included cases to represent the probable range of lateral asymmetry of wagon No. 641063 (paragraph 79) as well as other cases to include the limits shown in figure 13 (also shown in figure 14). Some of the key cases which are referred to in the following paragraphs are:

- Case 01 (the 'base case') represents the RAIB's assessment of the most likely weight distribution (actual weights carried and estimated lateral and longitudinal offsets) of wagon No. 641063 on 15 October 2013;
- Case 02 comprises the wagon load being balanced longitudinally, but with a mean lateral axle weight ratio of 1.25 : 1 [27];
- Case 04 comprises the wagon being balanced laterally, but with a longitudinal weight ratio of 3 : 1 (the UIC guideline);
- Case 06 is similar to case 01, but features the lower limit of estimated lateral imbalance (paragraph 77);
- Case 08 is similar to case 01, but features the upper limit of estimated lateral imbalance (paragraph 77); and
- Case 09 is similar to case 01, but uses a maximum weight of 24 tonnes instead of the 28.83 tonnes actually carried; this represents the maximum longitudinal asymmetry that would have been consistent with Freightliner's loading standard at the time of the derailment at Duddeston Junction on 10 August 2007 (see paragraph 88d).

[27] Note: the UIC guideline is 1.25 : 1 for the most unbalanced axle.

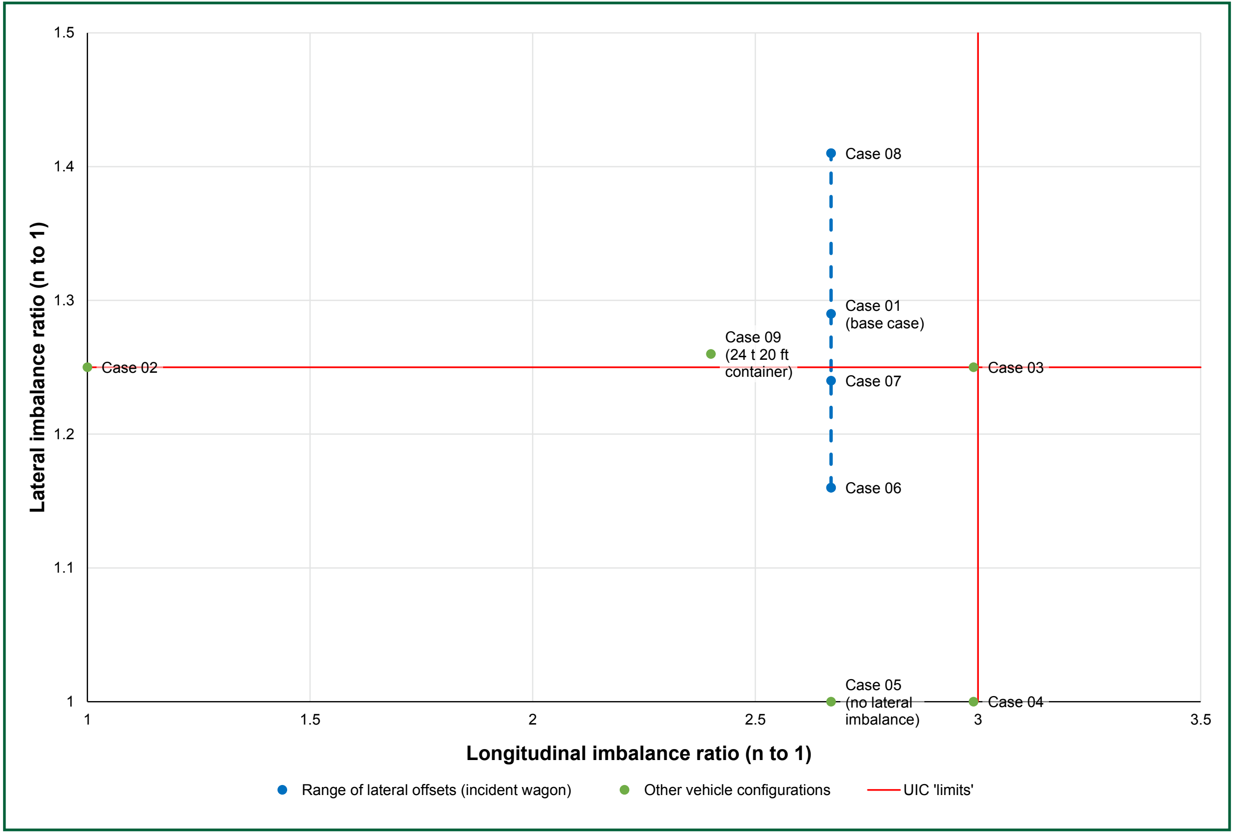


Figure 14: FEA loading configurations used for VAMPIRE® dynamic modelling

86 The results of the dynamic modelling showed:

a. The coefficient of friction (μ) between the wheels and rail was relevant to the probability of derailment. Case 01 was predicted to derail when $\mu \geq 0.23$ (a typical value for clean, dry rail), while the cases representing lower and higher levels of lateral asymmetry (cases 06 and 08) were predicted to derail when $\mu \geq 0.30$ and 0.14 respectively[28].

b. Both longitudinal and lateral asymmetry were necessary for derailment to occur. Neither case 04 nor case 02, representing the ‘limiting’ longitudinal and lateral weight ratios respectively, showed any tendency to derail in the absence of asymmetry along the other axis, irrespective of the values chosen for the other parameters modelled.

c. Reducing the weight of the 20 ft container to 24 tonnes (Case 09), while keeping the same values for the offset in the container’s centre of gravity (paragraph 76) significantly reduced the propensity of the wagon to derail.

[28] Standard NR/L3/TRK/3510/A01 states that lubrication is intended to reduce the coefficient of friction to 0.1-0.2.

Freightliner's rules for loading FEA wagons

87 **Freightliner had relaxed its rules on the loading of FEA wagons following the derailment at Duddeston Junction in 2007, allowing greater longitudinal asymmetry.**

88 Asymmetric loading of an FEA wagon was found to be a factor in the derailment of an FEA(B) wagon at Duddeston Junction in 2007 (see paragraph 123). Following the derailment at Duddeston Junction, Freightliner took the following actions (these are considered in more detail in appendix E):

a. It improved compliance with its loading standard, MIE 0767, which limited the weight of a 20 ft container carried next to an empty 40 ft container to 24 tonnes.

b. It commissioned VAMPIRE® modelling to determine the resistance of the FEA(B) wagon to derailment with differing longitudinal asymmetric loading[29]. This indicated that the wagon was sensitive to track twist, failing the requirements of GM/RT2141 Appendix A when lateral asymmetry was present; the extent of non-compliance was increased by greater longitudinal asymmetry (see paragraph E2, appendix E).

c. In May 2009 Freightliner submitted a research proposal to RSSB[30] to quantify both the extent of and risk from lateral asymmetric loading of freight wagons (see following paragraphs).

d. In July 2010 Freightliner amended MIE 0767 to permit the carriage of 20 ft containers weighing up to 30 tonnes next to 40 ft containers weighing up to 9.3 tonnes. This regularised the longitudinal asymmetry that had been present in the derailment at Duddeston Junction (but which had been contrary to Freightliner's loading standards at the time) into the loading standard. The increase in longitudinal asymmetry permitted by MIE 0767 was deemed to be acceptable by Freightliner based on advice from RSSB that the standards (including GM/RT2141) had been written to accommodate a degree of lateral asymmetry that had probably been present in typical operation of container wagons since their introduction to service. RSSB advised Freightliner that lateral offset loading did not need to be considered unless there was evidence that the loading configurations of containers or wagons had changed. Based on its experience in the intermodal container transport business, Freightliner concluded was that there had been no change and therefore it was correct to apply the requirements of GM/RT2141 in this way.

[29] The conditions modelled included an empty 40 ft container carried next to a 20 ft container weighing either 24 or 30 tonnes.

[30] A not-for-profit company owned and funded by major stakeholders in the railway industry, and which provides support and facilitation for a wide range of cross-industry activities. The company is registered as 'Rail Safety and Standards Board', but is known as 'RSSB'.

89 Freightliner's research proposal (paragraph 88c) sought to:

a. assess the degree of lateral offset loading actually prevalent on the mainline railway;

b. establish the norm and deviation of freight train loadings with respect to lateral asymmetry;

c. predict the level of derailment risk present in the railway, and quantify the restrictions that may be needed to 'influence' it; and

d. compare the benefits arising from a lower risk of derailment achieved by imposing the restriction with any costs that would also arise, using quantified risk assessment and industry guidance on the application of cost/benefit techniques.

90 The research proposal was considered on 14 July 2009 by the Vehicle/Vehicle System Interface Committee (VV SIC), which is administered by RSSB on behalf of the railway industry. VV SIC subsequently delegated the preparation of a paper summarising the discussion to one of its RSSB members. Although VV SIC includes representation from freight operators, Freightliner was not directly represented at the committee and has no record that it was asked to provide any input to the follow-up paper, which was submitted to the Rolling Stock Standards Committee on 4 December 2009. This paper reported that the following points had been made during the discussion at the system interface committee:

a. 'Some level of asymmetric loading in freight wagons is inevitable and is included in the implicit margin[31] … but the amount of margin is not known.'

b. 'The rail freight operators have no control over the load distribution inside bonded containers …'

c. 'There is no reason to believe that the amount of offset loading in containers or in other wagon types has changed significantly.'

d. '… it is not clear how [information on asymmetry] could be used'

91 The Rolling Stock Standards Committee concluded that the cost of undertaking the research would be disproportionate to the benefits to be obtained and that no further work should be undertaken. Freightliner's research proposal was not progressed by the industry.

92 RSSB has advised the RAIB that the historic norm is an empirical concept that covers unquantified conservative margins inherent in GM/RT2141. There is no specific requirement to review this historic norm when a change is introduced, although any changes should be 'justified'. The RAIB has seen no evidence that any work was carried out to verify that reliance on the historic norm was still appropriate, either when FEA wagons were accepted in 2003 or when Freightliner reissued MIE 0767 in 2010 (paragraph 88d). The relevance of the historic norm to FEA wagons is discussed further at appendix F; in particular, the RAIB has summarised a number of changes that might have undermined the application of the historic norm to operation of FEA wagons with asymmetric loading at paragraph F3.

[31] This margin is encompassed by the concept of the *historic norm* (see paragraph 92).

93 Recommendation 6 of the RAIB's report into the derailment at Duddeston Junction (paragraph 133a) required Freightliner to re-evaluate the FEA(B) wagon wheel unloading performance to ensure compliance with GM/RT2141. In September 2008, Freightliner wrote to ORR to state that compliance with the requirements of the standard under even small levels of lateral offset would 'cause a significant level of restriction of allowable loading configuration.' After Freightliner relaxed the loading restrictions in MIE 0767 (paragraph 88d), the RAIB wrote to advise ORR that the actions taken in response to the recommendation had the effect of increasing the risk associated with asymmetric loading.

94 As discussed at paragraph 108, the RAIB has seen no evidence that any organisation had carried out a detailed quantification of the risk arising from derailments of FEA wagons with asymmetric loading. Nevertheless ORR concluded that, as the results of the VAMPIRE® modelling commissioned by Freightliner (paragraph 88b) did not predict derailment, 'the risk is limited to less than what we would consider unreasonable and would act upon.' The modelling results to which ORR referred did not include lateral asymmetry (paragraph E2, appendix E).

The sensitivity of FEA wagons to twisted track

Derailment history of FEA wagons

95 **The operational history of the FEA wagon suggests that it may be particularly prone to flange-climbing on twisted track when loaded asymmetrically.**

96 The RAIB has reviewed data[32] for 23 derailments of FEA wagons that occurred between 2005 and 2013, to identify those which might have been associated with asymmetric loading (figure 15). Since the derailment at Duddeston Junction on 10 August 2007, there have been at least four other low-speed derailments on twisted track involving FEA wagons carrying a heavily-laden 20 ft container next to an empty 40 ft container; these include the derailment at Primrose Hill on 15 October 2013 (paragraphs 123 to 125). All five derailments involved longitudinal wagon weight ratios greater than 2.4 : 1 (the maximum that was consistent with the version of Freightliner's loading standard MIE 0767 current in 2007 (paragraph 32)). In four cases the load in the 20 ft container was subsequently observed to have been offset laterally, including the derailment on 15 October 2013. In the fifth case no information is available on the degree of lateral offset.

97 Data for derailments of FSA/FTA wagons (comparable 60 ft flat bed wagons) dating back to 2005 has been examined by the RAIB and compared with that for FEA wagons[33]. The number and nature of previous derailments suggests that FEA wagons similar to the type that derailed (ie types FEA(B), FEA(D), FEA(E) and FEA(S)) possibly have a greater propensity to derail on twisted track, especially when asymmetrically loaded.

---

[32] Sources included the industry's safety management information system (SMIS) and Network Rail's daily incident reports.

[33] For reference, data from the National Vehicle Register administered by Network Rail shows there is a total of 696 FSA/FTA wagons compared with a total of 772 similar FEA wagons.

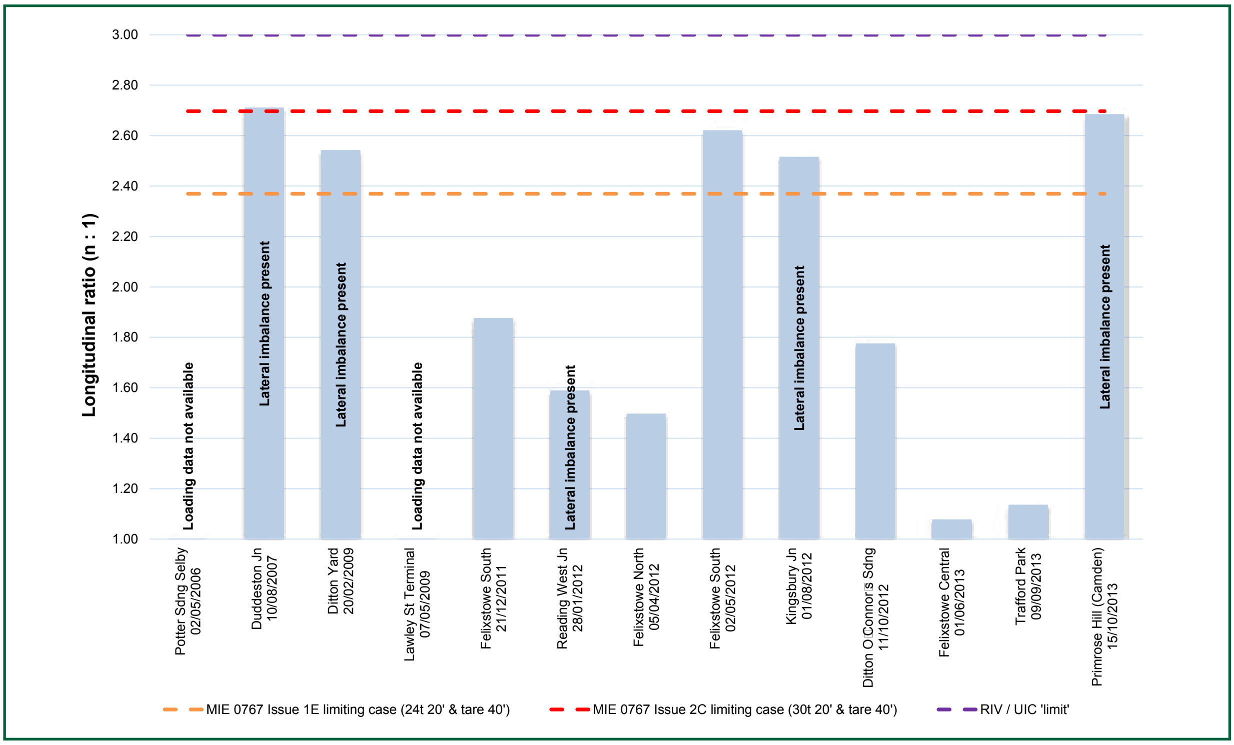


Figure 15: Low-speed derailments of FEA wagons with asymmetric loading

98 The apparent difference in the operational histories of FEA wagons and FSA/FTA wagons does not constitute definitive evidence of the FEA being more prone to derailment; the reasons for this apparent difference need to be understood. Earlier types of flatbed wagons such as the FSA/FTA type have a different design of chassis to that of the FEA (figure 16). The RAIB has been advised that the FEA chassis may have a higher degree of torsional stiffness as a result of the structural strength requirements of GM/RT2100, which came into force after the introduction of FSA/FTA wagons. To date it has not been possible to use a dynamic simulation tool to provide a valid comparison between the derailment performance of the FEA wagon that derailed on 15 October 2013 and an FSA wagon with the same container loading, as there is currently insufficient data available to compare the two types of wagon. However, additional VAMPIRE® modelling has found that a reduction in the torsional stiffness of the FEA wagon would have reduced the probability of derailment at Primrose Hill.

99 Although the evidence that the FEA wagon is particularly prone to flange-climbing on twisted track when loaded asymmetrically is not conclusive, it indicates a need to evaluate further the FEA's resistance to derailment when exposed to a combination of these conditions. Because of the apparent similarity of the derailment at Primrose Hill on 15 October 2013 with that at Duddeston on 10 August 2007, the RAIB issued urgent safety advice to the railway industry on 6 November 2013, regarding the risk of derailment of FEA wagons when unevenly loaded; this is included at appendix H.

Figure 16: Different structural design of flatbed wagons

Identification of underlying factors[34]

Vehicle acceptance process for the FEA(E) wagon

100 **The effect of asymmetric loading on the resistance of the FEA(E) wagon to derailment on twisted track was not considered as part of the process for accepting the wagon for operation on Britain's railway infrastructure. This is a possible causal factor.**

101 The compliance of FEA wagons with Railway Group Standards, including GM/RT2141, was assessed by Network Rail's Vehicle Conformance Group, which acted as the *Vehicle Acceptance Body* (VAB) for the wagon. Acceptance of the FEA(E) wagon was by comparison with the similar twin FEA(B) wagons. Acceptance of the FEA(B) wagon is discussed at paragraphs 105 to 113 of the RAIB's report into the derailment at Duddeston Junction on 10 August 2007 (report number 16/2008). In summary, asymmetric loading was not considered when the FEA(B) wagon was accepted, with the exception of simulations of high speed ride performance in a partially laden condition.

[34] Any factors associated with the overall management systems, organisational arrangements or the regulatory structure.

102 The company which carried out the wheel unloading tests defined at Appendix A of GM/RT2141, on behalf of Greenbrier, and the VAB both appear to have assumed that the limiting cases for these tests were empty and fully laden. Because the FEA(B) wagon met the requirements of Appendix A and the bogie rotation test defined at Appendix B, there was no requirement for it to be assessed against Appendix C (figure 7). The tests were carried out without any asymmetry, either longitudinal or lateral, despite the requirement to assess 'all significant representative conditions' (paragraph 35).

103 The specification drawing against which Greenbrier designed the FEA(E) (see appendix I) showed a maximum weight of 23.60 tonnes for a 20 ft container with an adjacent maximum weight 40 ft container (30.48 tonnes). It also showed 20 ft containers weighing 30.48 tonnes carried at opposite ends of the wagon. It did not show the maximum permissible weights for a 20 ft container when carried with an empty 40 ft container. Greenbrier has advised that the drawing does not show how to load the wagon and that Freightliner did not present any requirements regarding uneven distribution of wagon load. However, the RAIB's investigation into the derailment at Duddeston Junction found that Greenbrier had understood Freightliner's intention that each container could 'have a gross weight between the empty weight and the maximum weight indicated'. The resulting longitudinal weight ratios explicit in the specification and implicitly permitted by MIE 0767 (paragraphs 31 and 32) are shown in table 2.

	Container weight (A) – type / tonnes	Container weight (B) – type / tonnes	Longitudinal weight ratio
Maximum weights FEA(E) specification	20 ft / 23.60	40 ft / 30.48	1.22 : 1
Maximum asymmetry FEA(E) design	20 ft / 23.60	40 ft / 3.64	2.35 : 1
Maximum asymmetry MIE 0767 issue 1E	20 ft / 24.00	40 ft / 3.64	2.37 : 1
Maximum asymmetry MIE 0767 issue 2C	20 ft / 30.00	40 ft / 3.64	2.70 : 1

Table 2: Longitudinal weight ratios for FEA(E) wagon in various loading conditions

104 The VAB did consider some intermediate loadings of the FEA(B) wagon when assessing its high-speed ride performance against Appendix D of GM/RT2141 (figure 7). These were modelled using computer simulation instead of an on-track test. The intermediate loadings were intended to take account of operation at the changeover point between the 'tare' springs, designed for operation when the wagon is lightly loaded, and the second set of 'laden' springs, which become compressed when the wagon is heavily laden. This condition was modelled with a longitudinal weight ratio of 1.5 : 1. However, this test was not intended to simulate the wagon's resistance to derailment due to flange-climb at low speed on twisted track.

105 RSSB has advised the RAIB that a VAB would normally rely on an ‘applicant’ to advise representative loading conditions to be considered during vehicle acceptance. Freightliner did not explicitly declare intermediate loading conditions to the VAB, and paragraph 113 of the RAIB’s report 2008/16 identifies that the VAB reached a different understanding of the loading conditions for the wagon from that held by both Freightliner and Greenbrier.

The absence of ownership of the issue of derailments caused by asymmetric loading of freight vehicles

106 **Following previous similar derailments, neither the *duty holders*, Freightliner and Network Rail, nor RSSB had fully quantified the risk from operation of FEA wagons with asymmetric loading or determined whether measures were required to mitigate the risk.**

107 The track geometry and its condition, the asymmetric loading of the wagon and possibly the wagon characteristics were all factors in the derailment at Primrose Hill on 15 October 2013 (paragraph 43). Low-speed derailments involving asymmetrically loaded FEA flatbed wagons on twisted track, such as those identified at paragraphs 123 to 126, involve both the infrastructure manager and the freight operating company because both the track and the vehicle are causal factors.

108 The RAIB has seen no evidence that any organisation had carried out a detailed quantification of the risk arising from such derailments before the derailment on 15 October 2013. Freightliner’s research proposal (paragraph 88c) had included the undertaking of a quantified risk assessment, but this was not taken forward by the industry (paragraph 91). Freightliner’s Intermodal Executive had agreed in May 2009 that the risks had been reduced to ‘as low as feasible’ and that consideration of the costs and benefits of enforcing the 24 tonne maximum weight of a 20 ft container, when carried on an FEA wagon with a 40 ft container (paragraph 88a), indicated that such a restriction was not justified.

109 In addition to the duty holders themselves, RSSB has an interest in the risk arising from asymmetric loading. RSSB’s website[35] states that its role is to ‘help the industry understand risk, guide standards, manage research, development and innovation and collaborate to improve’. The following committees operate under the auspices of RSSB:

a. The Freight Technical Committee: this has convened the following sub-groups that have considered asymmetric loading:

   i. A one-off Asymmetric Loading Working Group[36], which met on 17 May 2012 following the derailment at Reading West Junction on 28 January 2012 (RAIB report number 02/2013). The working group concluded that ‘… using the current operating practice the issue was at a level that was ALARP’ (as low as reasonably practicable). The meeting chairman subsequently advised the RAIB that it had been a collective opinion, rather than the output of a risk assessment, that the level of risk from the issue was ALARP.

[35] www.rssb.co.uk/about-rssb/rssb-and-the-rail-industry.

[36] As well as RSSB, this group included representation from Direct Rail Services, Colas Rail, Freightliner, DB Schenker Rail, GB Railfreight and ORR.

ii. A GOTCHA limits working group, which met three times in 2013 to 'develop the remit for the development of the limits for unevenly loaded containers following GOTCHA activations'. It concluded that GOTCHA could potentially provide a method of measuring offset loading of freight wagons, although further work would be required to refine the measurement/ data analysis process. The sub-group was chaired by Network Rail and included representation from RSSB, the Private Wagon Federation, Freightliner and Direct Rail Services.

iii. An Intermodal Asymmetric Loading Working Group, which first met in February 2014 following the derailment at Primrose Hill; it was agreed this would meet bi-monthly. RSSB advised the RAIB that the meeting in April 2014 was not minuted and the meeting that was due to be held in June 2014 had been cancelled as the group had decided that any further work would require the production of a quantified risk assessment. The working group believed that this could be accomplished only using data obtained from GOTCHA (see footnote 25 to paragraph 84), which was not available. Network Rail was not represented at this sub-group.

b. The National Freight Safety Group (NFSG): its aim is to 'is to facilitate the improvement of safety in the rail freight industry through managing system risk.'

c. The Rail Freight Operators' Group (RFOG): this reports to the National Freight Safety Group and is concerned with tactical safety issues rather than strategic ones.

d. The Vehicle/Vehicle System Interface Committee (paragraph 90).

e. The Rolling Stock Standards Committee (paragraph 91).

110 Overall, the evidence contained in paragraphs 101 to 109 suggests that the industry's approach to understanding the risk from the asymmetric loading of freight wagons had not effectively co-ordinated the interests of infrastructure managers and freight operating companies[37]. In consequence, there was no knowledge of, or agreement about, the level of risk and whether this required the implementation of mitigation measures[38]. If such measures were required, there was no clear understanding of what these might be or how their cost might be shared between the duty holders.

111 In April 2014, RSSB and the Transport Research Laboratory jointly published a report entitled 'Potential risks to road and rail transport associated with asymmetric loading of containers'[39]. This included calculations of the safety risk and the cost of damage to infrastructure and rolling stock, as well as the cost of operational delays. It is possible that these calculations might be used to inform an industry review of potential risk mitigation measures, to determine whether any would be reasonably practicable.

---

[37] The different interests of the parties are reflected by the causal factors listed at paragraph 43.

[38] If the risk is already as low as reasonably practicable, no further mitigation would be required.

[39] This is available at www.trl.co.uk/reports-publications/.

112 Potential risk mitigation measures that might be assessed for reasonable practicability include:

a. Changes to track inspection and maintenance criteria, to consider track twists over distances relevant to the bogie spacing of modern freight vehicles (paragraph 48). Track twist is more likely to be an issue for freight-only lines, marshalling yards and at *switches & crossings*, for which twist may be an unavoidable design feature. However it might be possible to take a risk-based approach to prioritise those locations where there is consequential risk due to the potential for secondary collisions. The management of twist at such locations is currently being examined as part of RAIB's investigation into a derailment at Angerstein Junction on 2 April 2014.

b. Changes to track inspection and maintenance criteria, to consider the efficacy of time-based intervention limits that are much shorter than the intervals between measurements of track geometry.

c. Improvements to lubrication at the wheel/rail interface. Network Rail's current standard covering rail-based lubrication does not refer to its contribution to reducing the probability of flange-climb derailments (paragraph 65). Consideration might be given to installing more effective rail lubricators, targeted at reducing the risk of derailment, or fitting flange lubricators to specific types of vehicle.

d. Reducing the permissible longitudinal weight ratio for flatbed wagons. This would require changes to wagon loading patterns, which might impose problematic operational constraints on wagon loading[40].

e. Limiting lateral asymmetry of loading on wagons before they leave freight terminals[41]. This might require the installation of corner-weighing systems on container handling equipment or wheel-weighing equipment on depot departure lines. Consideration might also be given to limiting the longitudinal asymmetry of wagons carrying containers with lateral asymmetry.

f. Possible modifications to wagons (eg FEA type), such as changes to the suspension characteristics. However, such measures are also likely to affect other performance characteristics of the wagons.

g. Reducing the length of new wagons so as to reduce the potential for longitudinal asymmetric loading.

[40] Both Freightliner and GB Railfreight have carried out assessments of the numbers of containers that would have to be 'left behind' if loading restrictions were to be applied to FEA wagons.

[41] This is the subject of recommendation 3 of the RAIB's report into the derailment at Reading West Junction on 28 January 2012, paragraph 134a.

The lack of continuity within Euston MDU

113 **There was insufficient awareness of the condition, history and classification of the North London lines among the managers of the Euston Maintenance Delivery Unit.**

114 Improving the condition of the North London lines did not have a high priority within LNW(S), which also includes the southern section of the West Coast Main Line. Witnesses report that there was a lack of awareness in the Euston MDU that the North London lines should have been maintained as passenger, rather than freight-only, lines. A 'strategic renewal' to replace sections of jointed track on the Down North London line with CWR had been proposed by the previous Route Asset Manager (Track) for LNW(S), but it had not been identified as a priority for delivery in Control Period 4 (which ended in March 2014) and it had not been progressed. Following the joint site inspection by the TME and the Route Asset Manager (Track) in June 2013, paragraph 55, a number of items were compiled for possible delivery during Control Period 6 (April 2019 to March 2024).

115 This lack of awareness may have resulted from a large number of changes in personnel occupying roles with responsibility for maintenance of the track. Witnesses have advised the RAIB that the turnover in personnel started during 2010, in the period leading up to a reorganisation of Network Rail's maintenance function. The lack of continuity continued up until the appointment of the current Infrastructure Maintenance Delivery Manager in February 2012. The current Route Asset Manager (Track) for LNW(S) was appointed shortly afterwards, in April 2012. Key roles affected within the Euston MDU include:

a. the Infrastructure Maintenance Delivery Manager, the current incumbent is the fourth since January 2011;

b. the Infrastructure Maintenance Engineer, who was formally appointed in March 2013 after acting in the role since October 2012;

c. the Track Maintenance Engineer, who was formally appointed in June 2013 after being seconded into the role in April 2012 (the previous TME had been in post only since September 2011); and

d. the Section Manager (Track), who was formally appointed in January 2013 after being seconded into the role in May 2012 (there had been four acting section managers since 2010).

116 Witnesses report that the prevailing culture within Euston MDU at the end of 2012 and into 2013 had been one of 'fire-fighting'. The Infrastructure Maintenance Engineer, whose previous experience had been in track maintenance, was covering a vacancy in the Signalling and Telecommunications Maintenance Engineer position. The principal concerns with respect to track maintenance related to the risk from buckled rails and rail defects in the immediate approach to Euston station, as well as maintaining the required level of performance on the DC (direct current) electrified lines used by London Overground trains. Consequently, the generally poor condition of the North London lines (paragraph 54) did not have a high priority.

Discounted factors

117 The train was slightly exceeding the speed limit of 15 mph (24 km/h). The VAMPIRE® dynamic modelling, paragraph 43, demonstrated that, at 17 mph (27 km/h), the train was running with marginal cant deficiency (ie with some weight transferred to the outer rail). The effect of the increased load on the outside wheels was to reduce the probability of derailment. Therefore, the excess speed slightly reduced the probability of derailment.

118 The RAIB examined the wagon following the derailment and found no evidence of any defect that would have increased its bogie rotational resistance or other relevant defect in its condition that would have influenced its resistance to derailment on twisted track.

119 VAMPIRE® dynamic modelling has enabled the effects of wheel wear, rail wear and variations in the track gauge to be discounted as possible factors in the derailment.

Factor affecting the severity of consequences

120 **The spigots on the wagon did not restrain the 40 ft container following the derailment.**

121 The empty 40 ft container on wagon No. 641063 became dislodged from its retaining spigots when the trailing bogie of the wagon collided with the crossing at Camden Road West Junction (paragraph 19). It subsequently toppled from the wagon and demolished an overhead line stanchion, which collapsed across the Down North London line (figure 17).

Figure 17: 40 ft container, dislodged from wagon 641063, and collapsed overhead line stanchion

122 The spigots on FEA wagons are designed to comply with UIC leaflet 571-4, 'Standard wagons – Wagons for combined transport'. Such spigots are purposely designed not to retain containers when there is a large vertical force and small lateral force (such as when a container is lifted from a wagon by a crane). This combination of forces is typical of a derailment, and the loss of containers from flatbed wagons with spigots is a feature RAIB has seen in a number of previous derailments, including Duddeston Junction on 10 August 2007 and Gloucester on 15 October 2013. This is a different mechanism from the overturning of containers from FEA wagons as a result of strong side-winds, as occurred in the accidents near Cheddington and Hardendale on 1 March 2008 (RAIB report number 12/2009).

Previous occurrences of a similar character

123 On 10 August 2007, a pair of FEA(B) wagons forming part of a Freightliner train from Birmingham to the Isle of Grain became derailed at Duddeston Junction; the train was travelling at just under 15 mph (24 km/h). Both derailed wagons suffered damage to their running gear and around 200 metres of track required repair or replacement. One empty container fell from the train onto the track.

124 This was investigated by the RAIB (report number 16/2008). The immediate cause of the accident was the flange of the front right-hand wheel of the rear wagon climbing the rail as a result of the interaction between the combination of track twists and the unevenly loaded wagon. This wagon was carrying an empty 40 ft container and a loaded 20 ft container weighing 30.4 tonnes; estimates suggested the load had been offset laterally by between 250 and 400 mm. Recommendation 6 of the RAIB's report is relevant to the current investigation (see paragraph 133a).

125 Subsequently, derailments on twisted track of FEA wagons with significant longitudinal asymmetry have occurred at Ditton Yard, near Speke, Merseyside, on 20 February 2009, Felixstowe South Terminal, Suffolk, on 2 May 2012 and at Kingsbury Junction, near Tamworth, Warwickshire, on 1 August 2012. The RAIB did not investigate these derailments as they occurred in yards rather than while the trains were operating on the main line[42].

126 On 28 January 2012, an FEA wagon derailed and then re-railed when traversing a crossover near Reading. The RAIB's investigation (report number 02/2013), found that the derailment was caused by insufficient load on the front right-hand wheel of the wagon to prevent its flange from climbing over the rail head. This was the combined result of uneven loading on the wagon, specifically a lateral offset of the payload in the container, and the effect of a twist fault on the crossover. Recommendation 3 of the RAIB's report is relevant to the current investigation (see paragraph 134a).

[42] The scope of the RAIB's investigation is defined in the Railways (Accident Investigation and Reporting) Regulations 2005 and does not include railways that run within an industrial curtilage such as a harbour, freight terminal, mine, quarry or factory.

Summary of conclusions

Immediate cause

127 The leading right-hand wheel of the trailing bogie on wagon No. 641063 derailed after its flange climbed up and over the rail (**paragraph 39**).

Causal factors

128 The causal factors were:

a. The track had opposing twist faults which significantly reduced the load on the first wheel to derail (**paragraphs 46 and 136, Recommendation 1**).

b. There was no check rail on the tight radius curve to provide lateral restraint to the wheels of the wagon and prevent flange-climbing as it negotiated the curve (**paragraph 58, recommendation 1 of the RAIB's investigation into the derailment at Ordsall Lane Junction on 23 January 2013, see paragraph 135b**).

c. The combination of longitudinal and lateral asymmetric loading of the wagon. Linked factors include:

i. the extent of asymmetric loading of wagon No. 641063, which reduced the load on the right-hand rear wheels (**paragraph 82, Recommendation 2**); and

ii. the rules on the loading of FEA wagons had been relaxed following the derailment at Duddeston Junction in 2007, allowing greater longitudinal asymmetry (**paragraph 87, Recommendation 2**).

129 It is possible that the following factor was causal:

a. The level of friction between wheel and rail may have increased the probability of derailment (**paragraph 62, recommendation 1 of the RAIB's investigation into the derailment at Ordsall Lane Junction on 23 January 2013, see paragraph 135b**).

130 The RAIB also concluded that:

a. lateral track irregularities increased the probability of derailment by increasing the lateral forces at the wheel/rail interface (**paragraph 68, Recommendation 2**); and

b. there is a possibility that the FEA(E) wagon is particularly prone to flange-climbing derailment on twisted track when loaded asymmetrically (**paragraph 95, Recommendation 2**).

Underlying factors

131 The underlying factors were:

a. The effect of asymmetric loading on the resistance of the FEA(E) wagon to derailment on twisted track was not considered as part of the process for accepting the wagon for operation on Britain's railway infrastructure (**paragraph 100, Recommendation 3**).

b. Following previous similar derailments, neither the duty holders, Freightliner and Network Rail, nor RSSB had fully quantified the risk from operation of FEA wagons with asymmetric loading or determined whether measures were required to mitigate the risk (**paragraph 106, Recommendation 2**).

c. There was insufficient awareness of the ongoing poor condition and classification of the North London lines (both as a passenger route and as category 3 track) among the managers of the Euston Maintenance Delivery Unit (**paragraphs 51 and 113, Learning point 1**).

Factor affecting the severity of consequences

132 The following factor exacerbated the consequences of the event:

a. The spigots on the wagon did not restrain the 40 ft container following the derailment (**no recommendation**).

Previous RAIB recommendations relevant to this investigation

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

Previous recommendations that could have affected the factors identified in this investigation

134 The RAIB considers that more effective implementation of the following recommendation might have resulted in actions that could have prevented this derailment or else mitigated its consequences:

a. Derailment at Duddeston Junction, 10 August 2007 (report 16/2008, published July 2008)

<u>*Recommendation 6*</u>

Freightliner should arrange that the FEA-B wagon wheel unloading performance is re-evaluated taking into account the full range of load conditions they permit (currently defined in MIE 0767) to confirm compliance with GM/RT 2141. This should consider sensitivity to longitudinal and lateral offsets in load that can reasonably be encountered in service.

ORR reported (March 2011) that Freightliner had carried out modelling of an FEA wagon carrying an empty 40 ft container, together with a 20 ft container weighing 30 tonnes (with no lateral asymmetry), against the requirements of GM/RT2141. ORR concluded that the risk was not unreasonable (paragraph 94) and that the recommendation had been implemented by alternative means.

Previous recommendations that are currently being considered by the railway industry

135 The following recommendations were made by the RAIB as a result of previous investigations, which address factors identified in this investigation. They are therefore not remade so as to avoid duplication:

a. Freight train derailment at Reading West Junction on 28 January 2012 (report 02/2013, published January 2013).

<u>*Recommendation 3*</u>

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.

ORR reported (December 2013) that it had agreed that Freightliner would not be able to develop an industry-wide solution in isolation. ORR supported the Freight Technical Committee's approach to the potential use of Network Rail's GOTCHA system in two stages:

i to determine alarm limits; and

ii to consider how this information can be used operationally to mitigate the risks.

ORR has also reported that it would ask operators to clarify how they intend to prevent load offsets from entering traffic.

b. Locomotive derailment at Ordsall Lane Junction, Salford, 23 January 2013 (report 07/2014, published March 2014).

Recommendation 1

Network Rail should identify all curves that are non-compliant with Railway Group Standard GC/RT5021 and Network Rail standard NR/L2/TRK/2102 in respect of the need to fit a check rail. For each identified curve, Network Rail should implement measures to adequately mitigate the risk of derailment. These may include one or both of the following methods, although other means of mitigation may also be appropriate:

- *installing a check rail on the curve; and*
- *managing rail lubrication on the curve to a suitable level of availability.*

Implementation of this recommendation may require Network Rail to review curvature information recorded on track geometry measurement train runs.

No report received has yet been received from ORR on progress with this recommendation.

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

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

136 Network Rail has lifted and packed the track in the vicinity of the point of derailment to correct the twist faults.

Learning point

137 The RAIB has identified the following key learning point[43]:

1 Network Rail is reminded to give particular attention to the possible consequences of a high turnover of responsible staff with detailed local knowledge of the infrastructure, such as may occur during reorganisations of its maintenance function (paragraph 131c)[44].

[43] 'Learning points' are intended to disseminate safety learning that is not covered by a recommendation. They are included in a report when the RAIB wishes to reinforce the importance of compliance with existing safety arrangements (where the 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.

[44] It should be noted that organisational change falls within the scope of the common safety method on risk evaluation and assessment (European Commission Regulation No. 352/2009, available from http://eur-lex.europa.eu/).

Recommendations

138 The following recommendations are made[45]:

1 *The intent of this recommendation is to reduce the probability of track geometry defects remaining undetected in the event that operation of a track geometry measurement train does not take place as scheduled.*

Network Rail should provide specific guidance to managers with responsibility for track maintenance on the action to be taken to confirm that track quality remains acceptable should a planned run of a track geometry measurement train over a section of line be cancelled (paragraph 128a). This should include the criteria for whether it is necessary to conduct additional track geometry measurements, as well as the timescales for any such measurements to be completed.

continued

[45] Those identified in the recommendations, have a general and ongoing obligation to comply with health and safety legislation and need to take these recommendations into account in ensuring the safety of their employees and others.

Additionally, for the purposes of regulation 12(1) of the Railways (Accident Investigation and Reporting) Regulations 2005, these recommendations are addressed to the Office of Rail Regulation 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.raib.gov.uk.

2 *The intent of this recommendation is for the key stakeholders in the railway industry to work together to assess the risk from asymmetric loading and to identify and adopt reasonably practicable control measures to mitigate that risk.*

Freightliner and Network Rail should jointly request that RSSB:

a) researches the factors that may increase the probability of derailment when container wagons are asymmetrically loaded, and in particular:

   i. sensitivity to combinations of longitudinal and lateral offsets in loads that can reasonably be encountered in service;

   ii. the predicted performance of wagons with high torsional stiffness along their length (using the FEA type as an example); and

   iii. the effect of multiple twist faults, track twist over distances other than 3 metres (as commonly specified and measured by Network Rail) and lateral track irregularities.

b) updates and amends as necessary the risk assessment contained within the RSSB and Transport Research Laboratory joint report ('Potential risks to road and rail transport associated with asymmetric loading of containers'); this should take into account the results from the research referred to in a) and additional evidence presented in this investigation report; and

c) works with industry stakeholders to use the outputs of a) and b) to identify, evaluate and promote adoption of any additional reasonably practicable mitigations[46] capable of reducing the risk from asymmetric loading of wagons (paragraphs 128c, 130a, 130b and 131b).

3 *The intent of this recommendation is to clarify the requirements for the design and acceptance of freight wagons, taking account of the possibility of asymmetric loading.*

RSSB should amend Railway Group Standard 'Resistance of Railway Vehicles to Derailment and Roll-Over', GM/RT2141 to refer specifically to asymmetric loading, including possible combinations of longitudinal and lateral load imbalance (paragraph 131a).

[46] Consideration and evaluation to include, but not be limited to, those mitigations identified at paragraph 112.

Appendices

Appendix A - Glossary of abbreviations and acronyms

ALARP	As low as reasonably practicable
ΔQ/Q	See definition in appendix B
FEA, FSA/FTA and FWA	Types of flatbed wagons
ft	Foot (unit of measurement; 0.305 metres)
IMO	International Maritime Organisation
ISO	International Organization for Standardization
LNW(S)	Network Rail's London North Western Route (South)
MDU	Maintenance Delivery Unit
μ [mu]	Coefficient of friction
OTDR	On-train data recorder
RSSB	The not-for-profit company registered as 'Rail Safety and Standards Board'
TME	Track Maintenance Engineer
TRV	Network Rail's track geometry measurement train, sometimes referred to as the Track Recording Vehicle
UIC	Union Internationale des Chemins de Fer
UN ECE	United Nations Economic Commission for Europe
VAB	Vehicle Acceptance Body
VV SIC	Vehicle/Vehicle System Interface Committee
Y/Q	See definition in appendix B

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.

Asymmetric loading	A condition in which the centre of gravity of a vehicle (or a container) is offset from its geometric centre.
Centre of gravity	The point at which the entire mass of an object can be considered to be concentrated.
Check rail	An additional rail mounted alongside the inside rail of a curve to restrict the lateral movement of the wheels.
Coefficient of friction	The ratio of the force necessary to cause one surface to slide across another, divided by the force normal to the surfaces.
Crossing	Part of the track layout at a junction, in which one track crosses another.
$\Delta Q/Q$	The difference between the nominal vertical wheel load (on level track) and the actual wheel load, expressed as a percentage of the nominal wheel load.
Duty holder	An organisation, or person which has a duty imposed on them by the law intended to protect the health and safety of employees and/or other persons.
Eccentricity	The offset in the centre of gravity of a container divided by the total length (longitudinal) or the total width (lateral). See also paragraph D2, appendix D.
Flange-climb	A fault condition in which the lateral force exerted on a rail wheel is sufficient to force the rotating wheel up the gauge face of the rail. Once the flange tip clears the rail head a derailment normally occurs. Flange-climb can be caused by a twist, excessive speed or severe sidewear.*
Flatbed wagons (also known as 'container flats')	Wagons with flat decks, designed to carry long or bulky items of freight, eg containers.*
Gauge corner	The curved profile of the rail head between running surface and running edge.*
Gauge face	The side of the rail head facing towards the opposite running rail, ie the face to which the track gauge is measured.*
GOTCHA	A trackside monitoring system manufactured by Lloyds Register Rail (www.gotchamonitoringsystems.com).
Historic norm [as used in this report]	A margin of conservatism that RSSB has advised is present to provide a margin of safety between the procedures and limit values in GM/RT2141 and GC/RT5021; see also appendix F.

Intermodal train	A train carrying cargo transport units designed to be carried on more than one mode of transport (eg train, lorry, ship). Typically, and in the case of 4L77, such cargo transport units are ISO containers.
Intervention limits	Limits for track geometry faults, beyond which corrective action is required within defined timescales.
Lateral weight ratio	For a wagon: the sum of the loads on the wheels on the heavier side of the wagon divided by the sum of the loads on the wheels on the lighter side. For an axle: the weight on the heavier wheel divided by the load on the lighter wheel.
Longitudinal weight ratio	The load on the axles of the heavier bogie divided by the load on the axles of the lighter bogie.
Lift and pack	The action of raising the track to its designed level and adding compacted ballast beneath the sleepers.*
Measured shovel packing	A manual technique for accurately addressing small vertical errors in the track. The lift required is measured, and an appropriate number of cans of chippings are introduced under the sleeper to achieve this lift.*
Normal distributions	Symmetrical bell-shaped graphs representing the distribution of random variables.
Railway Group Standard	A document mandating the technical or operating standards required of a particular system, process or procedure to ensure that it interfaces correctly with other systems, process and procedures.* Railway Group Standards are published and maintained by RSSB.
Routes	Ten strategic parts of Network Rail's infrastructure, which function as separate units with their own management for operating, maintaining and renewing the infrastructure.
Section manager	The person responsible for the day to day maintenance of the track within the Euston Maintenance Delivery Unit.
Spigots	A peg, in some cases retractable, used to retain containers laterally on a wagon deck.
Switch & crossing	Track that allows trains to move from one line to another.
Technical Specification for Interoperability	European legislation which mandates certain (minimum) common standards across the European Union, allowing "Inter-operation" without the need for territory specific modifications to vehicles.*
Track irregularities [as used in this report]	The deviations from an idealised curve fitted through the track survey data points.

Track twist	The change in the height of one rail relative to the other, measured over a defined distance along the track; this is normally 3 metres on Network Rail's infrastructure. It may be expressed in millimetres, or else as a gradient (eg 15 mm twist over 3 metres would be 1 in 200).
Twist fault	A value of track twist exceeding a specified threshold.
Vehicle Acceptance Body	A body given authority by RSSB to exclusively undertake engineering acceptance for rail vehicles.*
Vehicle acceptance	The process for engineering acceptance of railway vehicles, defined in Railway Group Standard GM/RT2000.
Wetbed	An area of ballast contaminated with slurry. Such wetbeds spread under the action of passing traffic and can cause twist faults in extreme cases.*
Wheel unloading	The extent to which the load on a given wheel reduces in specific circumstances. See also ΔQ/Q.
Wheelchex	A type of wheel impact load detector system manufactured by Delta Rail (formerly AEA Technology). Both rails on a section of straight and level track are instrumented and measure the load imparted by a moving wheel. A large variation in the load imparted by a single wheel indicates the presence of a wheel flat or an out-of-round wheel.
Y/Q derailment quotient	The ratio of lateral to vertical force at the wheel / rail interface.

Appendix C - Key standards current at the time

GM/RT2000 'Engineering Acceptance of Rail Vehicles', Issue 2, October 2000	RSSB Railway Group Standard
GM/RT2141 'Resistance of Railway Vehicles to Derailment and Roll-Over', Issue 3, June 2009	RSSB Railway Group Standard
GC/RT5021 'Track system requirements', Issue 5, December 2011	RSSB Railway Group Standard
NR/L2/TRK/001 'Inspection and Maintenance of Permanent Way'	Network Rail standard
NR/L2/TRK/2102 'Design and construction of track', Issue 6, 6 March 2010	Network Rail standard
NR/L3/TRK/3510/A01 'Lubrication of Plain Line Running Rails, Check Rails and S&C', Issue 1, 5 March 2011	Network Rail standard
MIE 0767 'Permissible Loading of Freightliner Intermodal Wagons', Issue 2 Rev C, 10/06/13	Freightliner management instruction
ISO 668:1995 'Series 1 freight containers - Classification, dimensions and ratings'	International standard published by the International Organization for Standardization
ISO 3874:1997 'Series 1 freight containers - Handling and securing'	International standard published by the International Organization for Standardization
Leaflet 571- 4, 'Standard wagons - Wagons for combined transport', 2nd Edition, January 1991, replaced by 4th edition, October 2004	Union Internationale des Chemins de Fer
'Loading Guidelines - Section 2 - Goods', published January 1998, as amended December 2010.	Union Internationale des Chemins de Fer

Appendix D - Asymmetric loading of containers

D1 Asymmetric loading of freight containers is undesirable whether the container is to be transported by road, rail or ship. Consequently various organisations have issued guidelines with a view to limiting the extent of asymmetry; some of these are summarised below. Asymmetry may exist when the container is originally packed; it may also develop as a result of the load shifting due to the forces acting on the container during transport. It should be noted that asymmetry becomes more significant with increasing mass of the load. When the load in a container is relatively low, the effect of load asymmetry is reduced by the other masses present (as an illustration, the payload of the 20 ft container on wagon No. 641063 was 50% of the gross weight of the wagon).

D2 Asymmetric loading of containers is typically quantified in terms of eccentricity. ETS Consulting[47] has provided the RAIB with the following explanation of eccentricity:

> *Eccentricity refers to position of the gross centre of gravity*[48] *from the geometric centre of the container. It can be measured in absolute terms (m) or as a percentage from the geometric centre. The gross centre of gravity should be as close to the geometric centre as possible. It is recognised that when packing containers it is not always possible to achieve this … Because of the example stated in ISO 3874* [see below]*, 5% is seen as the maximum acceptable degree of eccentricity.*

Note: The maximum theoretical eccentricity that is possible using the calculation method implied by ISO 3874 is 50%.

D3 Guidance and standards for the packing of freight containers were discussed in the RAIB's report into the derailment at Reading West Junction on 28 January 2012 (RAIB report Ref. 02/2013). Extracts from documents providing guidance relating to the packing of containers are given below:

a) IMO/ILO/UN ECE Guidelines for Packing of Cargo Transport Units (published by the International Maritime Organization in 1997)[49]

3.1.10 '*The centre of gravity of the packed cargo should be at or near the longitudinal centreline of the cargo transport unit and below half the height of the cargo space of the unit (see also 3.2.5 and other appropriate sections).*'

3.2.1 '*It is essential to make the cargo in a CTU secure to prevent cargo movement inside the unit…*'

---

[47] ETS Consulting provides engineering and safety support services for the freight transport supply chain, and has been involved in the publication of a number of documents relating to the packing of containers, including the IMO / ILO / UNECE Code of Practice (paragraph E3(b)).

[48] The gross centre of gravity is the combined centre of gravity of the cargo and the empty container.

[49] http://www.unece.org/fileadmin/DAM/trans/doc/2011/wp24/IMO_ILO_UNECE_Guidelines_packing_cargo_1997_01.pdf.

3.2.5 *'The weight of the cargo should be evenly distributed over the floor of a container. Where cargo items of a varying weight are to be packed into a container or where a container will not be full (either because of insufficient cargo or because the maximum weight allowed will be reached before the container is full), the stow should be so arranged and secured that the approximate centre of gravity of the cargo is close to the mid-length of the container. If it is not, then special handling of the container may be necessary. In no case should more than 60% of the load be concentrated in less than half of the length of a container measured from one end. For vehicles, special attention should be paid to axle loads.'*

b) IMO/ILO/UN ECE Code of Practice for Packing of Cargo Transport Units (published in 2014; available from the Inland Transport Committee of the Economic Commission for Europe)[50]

3.1.4 *'the cargo should be so arranged and secured in the freight container that its joint centre of gravity is close to the mid-length and mid-width of the freight container. The eccentricity of the centre of gravity of the cargo should not exceed ±5% in general. As a rule of thumb this can be taken as 60% of the cargo's total mass in 50% of the freight container's length. Under particular circumstances an eccentricity of up to ±10% could be accepted, as advanced spreaders for handling freight containers are capable of adjusting for such eccentricity.'*

c) Series 1 freight containers – Handling and securing, ISO 3874:1997 (published by the International Organization for Standardization)[51]

4.2.4 *'The cargo shall be distributed throughout the container to ensure that the centre of gravity is kept as central and as low as possible*

- *'to avoid excessive tilting;*
- *'to avoid overstressing either the container or the handling equipment;*
- *'to avoid unacceptable axle loading;*
- *'to avoid lack of vehicle stability;*
- *'to avoid unacceptable load concentrations.*

'Eccentricity of the centre of gravity for the loaded container varies with the distribution of load within the container; designers of containers and handling equipment should take this fact into account. As an example, when 60% of the load by mass is distributed in 50% of the container length measured from one end, the eccentricity corresponds to 5%.'

[50] This code of practice was published in January 2014 and has been ratified by the IMO and UN ECE; it was approved by the ILO with effect from 1 October 2014. It is available from www.unece.org.

[51] www.iso.org.

d) Safety in the supply chain in relation to packing of containers (published by the International Labour Organization)[52]

262. '*There is a very important difference between the two versions of the guidance notes. The ISO text refers to an example of load distribution, whereas the CTU* [cargo transport unit] *packing guidelines prohibit more than 60 per cent of the cargo's mass within 50 per cent of the container length – and many other publications also make this stipulation. Ideally, correct load distribution is of great importance and the mass distribution should not have an eccentricity of greater than 5 per cent in any direction, but there are instances where it is impossible to achieve this due to the nature of the cargo. Therefore, it is important that packers of containers understand the implications of the eccentric load.*'

e) Stow it Right! – ICHCA (International Cargo Handling Co-ordination Association) International Safety Panel Briefing Pamphlet No 21 (published by ICHCA International Limited)[53]

1.3 '*The IMO/ILO/UN ECE Guidelines for Packing of Cargo Transport Units and the other publications listed at the end of this booklet should also be consulted. These contain guidance that is, in some cases, less onerous than that contained in this pamphlet. As an example, the IMO Guidelines state "In no case should more than 60% of the load be concentrated in less than half of the length of a container measured from one end", whereas this publication recommends, for rail carriage of a laden container, that the weight of the load be evenly distributed from side to side and from end to end of the container, and to a uniform height of loading (insofar as loading permits). This is because of the additional problems that can arise due to vibration. Shippers should evaluate specific movements and take special precautions in the packaging, handling, stowing and securing of their cargo within containers.*'

D4 ETS Consulting has compiled data for containers handled at an unspecified British port between March 2012 and March 2014. A total of 174,508 measurements were made as part of this research, taken from various types of handling equipment used within the terminal. The weight distributions of 20 and 40 ft containers are shown at figure D1. The data indicates that approximately five percent of random combinations[54] would include a 20 ft container weighing 27 tonnes or more and a 40 ft container weighing 5 tonnes or less; such combinations carried on an FEA wagon would result in longitudinal weight ratios equal to or greater than 2.4 : 1.

[52] www.ilo.org.

[53] www.ichcainternational.co.uk.

[54] See footnote 20 to paragraph 73.

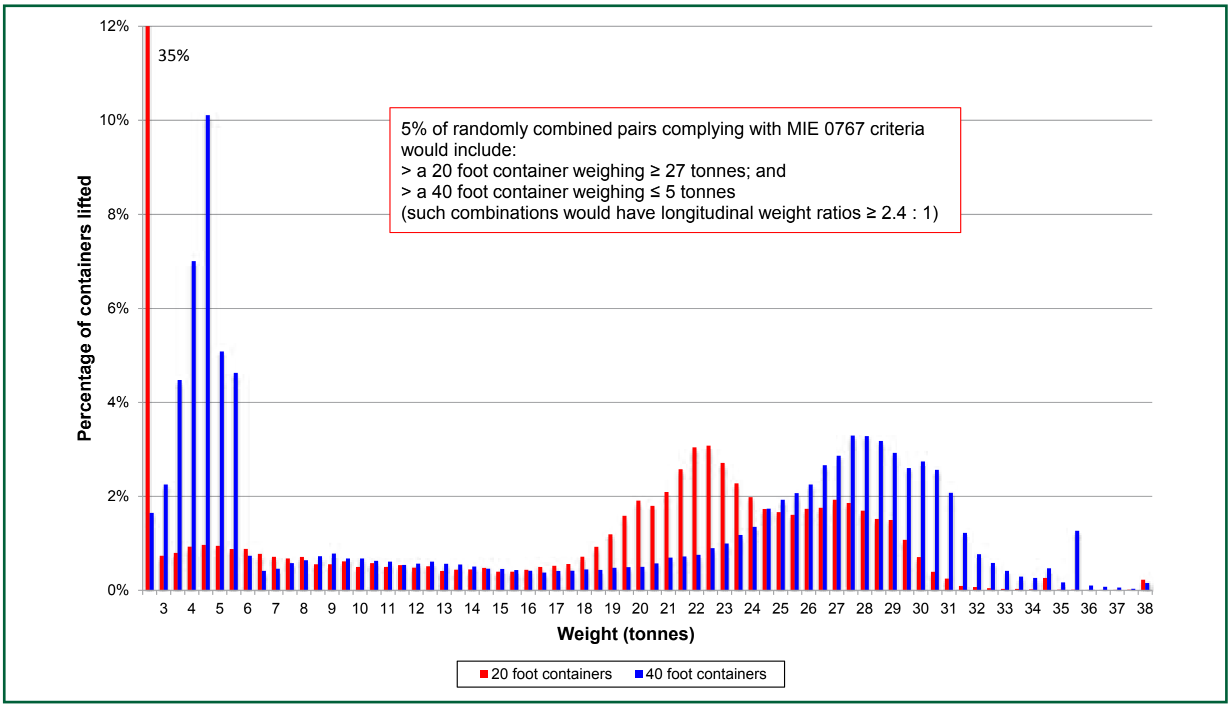


Figure D1: Weight distributions of 20 and 40 ft containers (2 years)

Appendix E - Freightliner's actions following the derailment at Duddeston Junction on 10 August 2007

E1 At the time of the Duddeston derailment, there had been widespread non-compliance with Freightliner's loading standard MIE 0767, resulting in containers weighing more than 24 tonnes being carried adjacent to 40 ft containers on FEA wagons. Following the derailment, Freightliner took steps to improve compliance (paragraph 88a); it told ORR on 26 September 2008:

- *… staff are being advised to work to MIE 0767 wherever possible* [ie maximum weight of 24 tonnes in a 20 ft container]*, but if loading combinations outside this requirement become a commercial imperative, then loading … 20 ft containers* [up to 30 tonnes] *is permitted.*
- *The compliance of this instruction is being monitored through random inspection … to see if loading combinations comply to MIE 0767 and if not, that the train could not be adjusted to comply.*
- *To date the monitoring has shown good compliance with the instruction, which provides a reduction of risk compared to pre-August 2007 where these checks were not in place.*

E2 Freightliner commissioned modelling of the FEA(B) wagon, loaded with a heavy 20 ft container and an empty 40 ft container. Based on this modelling, Freightliner concluded that the wagon's resistance to derailment with longitudinal load asymmetry was acceptable; it had been advised that lateral asymmetry did not need to be considered (paragraph 88b). This modelling included:

- Dynamic simulations to determine the resistance to flange-climbing derailment at low speed with longitudinal asymmetry (with a 20 ft container weighing either 24 or 30 tonnes); lateral asymmetry was not considered. The results also exceeded the limits in Appendix C of GM/RT2141, although the vehicle was not required to comply with these limits on the basis that it had satisfied the requirements of Appendices A and B.
- Simulations were also carried out of the wheel unloading test in Appendix A of GM/RT2141 with lateral offsets in the centre of gravity of 0 mm, 200 mm and 400 mm[55]. With a 200 mm lateral offset and a 20 ft container weighing 24 tonnes, the predicted wheel unloading was 64% (the GM/RT2141 limit is 60%); increasing the weight of the container to 30 tonnes increased the predicted wheel off-loading to 72%.

E3 Freightliner submitted a research proposal to RSSB, in response to recommendation 6 of RAIB report number 16/2008 and recommendation 9 of report number 10/2009 (paragraphs 89 to 91).

E4 Based on its conclusions from the dynamic modelling (paragraph E2) Freightliner reissued MIE 0767 in July 2010 (paragraph 88d). This permitted the maximum weight of a 20 ft container adjacent to a 40 ft container to be increased from 24 tonnes to 30 tonnes[56].

---

[55] It is unclear whether these offsets were in the centre of gravity of the wagon or of the loaded 20 ft container.

[56] When the 40 ft container is at the corresponding maximum (9.32 tonnes), the longitudinal weight ratio is 2.19 : 1. When it is empty (typical weight 3.64 tonnes) the longitudinal weight ratio consistent with Issue 2C of the standard is 2.70 : 1; this compares with 2.37 : 1 in Issue 1E.

E5 Freightliner implemented a software-based load management system, ‘Spinnaker’; this prohibits wagon loading that does not comply with the parameters defined in the revised MIE 0767.

E6 Freightliner issued guidance to staff involved in loading wagons with new guidelines. In summary, these stated that:

- the new rules departed from previous practice by allowing 20 ft containers weighing more than 24 tonnes to be loaded next to a 40 ft container;
- this was supported by computer modelling;
- Spinnaker had been programmed with the new rules; and
- as far as possible, the weights of two containers carried on the same wagon should be balanced.

Appendix F - The relevance of the historic norm to the FEA wagon

F1 RSSB has stated that the requirements of GM/RT2141 are not based on fundamental theoretical studies but on many years of service experience. It considers meeting the requirements to be sufficient to demonstrate that a vehicle is equivalent to or better than existing vehicles in fleet operation and is therefore acceptable in terms of derailment risk. If a new vehicle remains within the historic norm in terms of variations in these (undefined) parameters then the risk is deemed to be acceptable. If, for some reason, the new vehicle or its operation differ from the historic norm then RSSB considers that additional assessment may be required.

F2 The paper submitted to the Rolling Stock Standards Committee on 4 December 2009 (paragraph 88d) identified the following implications for the FEA(B) wagon:

- '*The Historic Norm implicitly includes margin for lateral and longitudinal offset of loads within containers and such conditions are not routinely tested*[57]*. The distribution of the containers on the wagon is the responsibility of the operator and their loading rules and differing conditions may be tested. The original acceptance of the FEA(B) wagons was in accordance with this principle. There is no evidence that the lateral distribution of loads within containers has significantly altered and therefore the conditions are believed to remain within the Historic Norm.*
- '*International conventions for carriage of ISO containers require the shipper to ensure even loading and the vast majority of containers are customs bonded, preventing internal inspection by the rail operator. There is therefore no method of assessing any lateral asymmetry of containers at loading points as lifting methods are required to compensate for external effects such as wind loading and thus are unable to detect sway resulting from offset loading.*'

F3 The RAIB has however identified a number of changes[58] that may be relevant to container traffic carried on FEA wagons, when considering the applicability of the historic norm developed over many years' experience:

- The growth in the numbers of 40 ft containers following the phasing out of 30 ft containers in the mid-1980s. Where a 40 ft container is carried on a 60 ft flatbed wagon, such as the FEA, this results in a 40 ft / 20 ft combination to maximise capacity.
- The increase in the maximum gross weight of 20 ft containers from 24 tonnes to 30 tonnes, following the introduction of road vehicles with a gross laden weight of 44 tonnes in 1994[59].
- The introduction of 9' 6" high containers, which potentially have a higher centre of gravity than 8' 6" types (note that 20 ft containers have a maximum height of 8' 6").

[57] This margin accounts for the normal, in-service, variation of a wide range of parameters.

[58] This is not an exhaustive list; the items quoted are given as examples and are not necessarily relevant to the derailment on 15 October 2013.

[59] This was permitted for the transport of goods to and from a rail head; it was permitted more generally from February 2001.

- Changes in the design of FEA wagons compared with earlier types (see paragraph 98).
- Possible changes in the pattern of imports and exports. The RAIB has been advised that a significant number of 20 ft containers loaded for export currently carry scrap of various types; these may return empty, whereas imports of finished goods may be carried in 40 ft containers.
- Historically, those planning the loading of wagons would try to balance wagon loads longitudinally. Freightliner has implemented a computerised system that ensures wagon loadings comply with the requirements of MIE 0767. However, due to the nature of the loading process, this sometimes results in empty spaces (eg 20 ft) being filled under software control, on a first-come, first-served basis. As a consequence, the opportunity for an experienced planner to optimise the load distribution between wagons on a train has been reduced.
- Freightliner has experienced frame cracking on its FSA/FTA 60 ft flatbed wagons. As a result, it has applied restrictions to the loading of heavy containers on these wagons. Consequently, heavy containers have tended to be preferentially carried on FEA wagons.
- Although the historic norm has not been defined, Freightliner has advised the RAIB that it has been considered only with reference to container wagons, ie that there has been no transfer of 'historic norm' experience between different types of wagon.

Appendix G - Extract from MIE 0767, ISSUE 2, REV C, 10/06/13

PERMISSIBLE LOADING OF FEA GREENBRIER CONTAINER WAGONS.

FEAB (outer wagon 82 tonnes GLW)

FEAE (single wagon 82 tonnes GLW)

75 mph Maximum Speed

- Each Greenbrier FEAB wagon has a GLW of 82tonnes and a payload of 62 tonnes. FEAB outer wagons are numbered 640001 to 640500.
- Each Greenbrier FEAE wagon has a GLW of 82tonnes and a payload of 61.5 tonnes. FEAE single wagons are numbered 641001 to 641066.
- Container weights are shown in gross tonnes and parts thereof if applicable.
- Container lengths are shown in feet.
- Wagon platform height at tare is 980mm above rail level.
- Loads that conform to the container exception gauge only travel on certain routes, which must be verified before loading.
- For conveyance of swap bodies consult WMFRS GO/RM3056.
- Loading configurations are based on a maximum 20.5t axle loading.
- Tanks loaded or empty can be loaded to any position on these wagons, subject to maximum axle loading.
- Empty containers/tanks may require to be pinned prior to travel should a severe weather warning forecast high winds.

Spigot locking pins:

Intermodal Control will issue advance information of weather conditions to all affected locations.

Where the centre weather forecast summary indicates winds in excess of 50mph will occur in the following 24 hr period, any Freightliner train conveying FEA(B) or FEA(E) wagons through an affected region will not have empty containers loaded to FEA(B) or FEA(E) wagons unless the empty containers are fitted with locking pins in which case the restriction will not apply.

The above conditions of travel do not apply to loaded containers.

Where trains are booked to be recessed over a weekend the forecasted wind speeds must be taken into consideration at the point of loading. Advanced weather notification can be sought from Intermodal Control. This is particularly relevant where trains are recessed in non-Freightliner locations.

Caution notes:

Containers with a tare weight of 1.6 tons or less are not permitted on wagons fitted with spigots.

Under no circumstances are 30 foot empty containers to be secured to FEA type wagons using the locking pins, as the two centre ISO corner castings on the containers if fitted with locking pins, will go out of gauge.

Greenbrier FEAB Rail Wagon	
Twenty foot container/tank	Forty foot container/tank
30 tonnes	**10.21 tonnes**
30.06 tonnes	10 tonnes
29.76 tonnes	11 tonnes
29.46 tonnes	12 tonnes
29.16 tonnes	13 tonnes
28.86 tonnes	14 tonnes
28.56 tonnes	15 tonnes
28.26 tonnes	16 tonnes
27.96 tonnes	17 tonnes
27.66 tonnes	18 tonnes
27.36 tonnes	19 tonnes
27.06 tonnes	20 tonnes
26.76 tonnes	21 tonnes
26.46 tonnes	22 tonnes
26.16 tonnes	23 tonnes
25.86 tonnes	24 tonnes
25.56 tonnes	25 tonnes
25.26 tonnes	26 tonnes
24.96 tonnes	27 tonnes
24.66 tonnes	28 tonnes
24.36 tonnes	29 tonnes
24.06 tonnes	**30 tonnes**
24 tonnes	**30.21 tonnes**
23.76 tonnes	31 tonnes
23.46 tonnes	32 tonnes
23.16 tonnes	33 tonnes
22.86 tonnes	34 tonnes
22.56 tonnes	**35 tonnes**

A. Loading containers in either 20/40 or 40/20 configurations on this type of rail wagon is permissible.

B. Forty foot containers weighing between tare and 10 tons may be placed and travel next to any 20 foot container weighing more than 1.6 tons.

Greenbrier FEAE Rail Wagon	
Twenty foot container/tank	Forty foot container/tank
30 tonnes	**9.32 tonnes**
29.79 tonnes	10 tonnes
29.49 tonnes	11 tonnes
29.19 tonnes	12 tonnes
28.89 tonnes	13 tonnes
28.59 tonnes	14 tonnes
28.29 tonnes	15 tonnes
27.99 tonnes	16 tonnes
27.69 tonnes	17 tonnes
27.39 tonnes	18 tonnes
27.09 tonnes	19 tonnes
26.79 tonnes	20 tonnes
26.49 tonnes	21 tonnes
26.19 tonnes	22 tonnes
25.89 tonnes	23 tonnes
25.59 tonnes	24 tonnes
25.29 tonnes	25 tonnes
24.99 tonnes	26 tonnes
24.69 tonnes	27 tonnes
24.39 tonnes	28 tonnes
24.09 tonnes	29 tonnes
23.79 tonnes	**30 tonnes**
24 tonnes	**29.33 tonnes**
23.49 tonnes	31 tonnes
23.19 tonnes	32 tonnes
22.89 tonnes	33 tonnes
22.59 tonnes	34 tonnes
22.29 tonnes	**35 tonnes**

A. Loading containers in either 20/40 or 40/20 configurations on this type of rail wagon is permissible.

B. Forty foot containers weighing between tare and 10 tons may be placed and travel next to any 20 foot container weighing more than 1.6 tons.

Appendix H - Urgent Safety Advice issued by the RAIB

URGENT SAFETY ADVICE

1. INCIDENT DESCRIPTION			
LEAD / INSPECTOR		CONTACT TEL. NO.	
INCIDENT REPORT NO	690	DATE OF INCIDENT	15 October 2013
INCIDENT NAME	Primrose Hill/Camden Road		
TYPE OF INCIDENT	Flange climb derailment leading to a container falling from a train.		
INCIDENT DESCRIPTION	On 15 October 2013, at around 02:40 hrs, the rear bogie of the 5th wagon of a loaded container train derailed on a running line in the vicinity of the disused Primrose Hill station, while travelling at around 17 mph (27 km/h). The train then ran with the bogie derailed for a distance of about 900 metres. At Camden Road West Junction, the derailed bogie collided with the trailing points, causing the suspension to collapse and the leading bogie of the same wagon to derail. This caused the rear container (of two) on the wagon to fall from the train, and collide with an overhead line stanchion. The damage to the track and to overhead line equipment resulted in the route through Camden Road being closed for six days. The wagon that derailed was carrying a loaded 20 foot container, weighing 29 tonnes, at the front and an empty 40 foot container, weighing 5 tonnes, at the rear. Trackside 'Wheelchex' data, post incident measurements and an examination of the container's contents suggest that the load in the front container may have been biased to the left. The track at the point of derailment was found to have a twist fault that was large enough to trigger a maintenance action within seven days (recorded statically as 15.3 mm and dynamically as 16.5 mm over 3 metres, compared to an initial maintenance threshold of 15 mm over 3 metres). This twist fault was, however, less than the 33 mm twist threshold which, if detected, would trigger an immediate blocking of the line. In addition to the 3 metre twist fault, the track was found to have an opposite twist of 43 mm between the rear bogie at the point of derailment and the position of the front bogie, 14 metres away. Network Rail does not routinely measure twist over track lengths above 5 metres, so this would not have been detected. The point of derailment was on a left hand curve, meaning that the leading right hand wheel of each bogie was most susceptible to flange climb. Although it is still to carry out a detailed analysis, the RAIB considers it likely that the unbalanced loading of the wagon and track twist combined to reduce the loading on the front right hand wheel of the rear bogie allowing it to flange climb into derailment.		
SUPPORTING REFERENCES			

2. URGENT SAFETY ADVICE	
USA DATE:	06 November 2013
TITLE:	Derailment risk to FEA bogie container wagons
SYSTEM / EQUIPMENT:	FEA bogie container wagons when unevenly loaded.
SAFETY ISSUE DESCRIPTION:	FEA wagons are running over infrastructure with loads distributed in a way that makes them susceptible to derailment on track twists that the infrastructure maintenance standards allow to be present for a defined period of time before rectification.

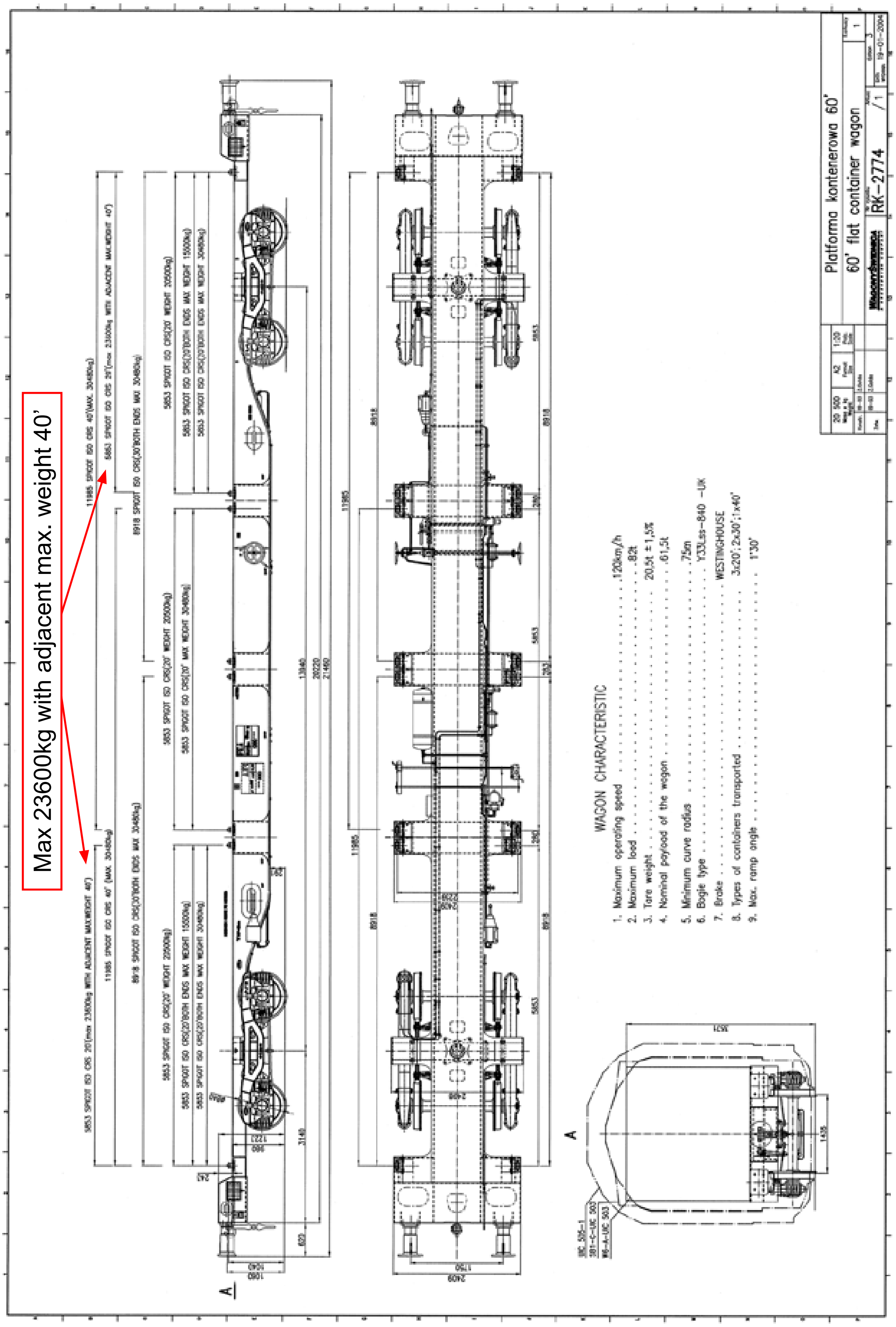
.

Urgent Safety Advice

Circumstances:	This incident has marked similarities to a previous incident at Duddeston Junction (10 August 2007) and similarities to a number of siding incidents since. In these incidents FEA wagons carrying a combination of unevenly distributed longitudinal and lateral loads have become derailed when travelling over track twists. At Duddeston Junction, an FEA wagon carrying a loaded 30 tonne, 20 foot container, with the load slightly laterally offset, and an empty 40 foot container derailed at around 15 mph (24 km/h) at a location where there was a combination of track twists that were such as to require maintenance action but not sufficient to trigger a line blockage.
Consequences	Potential derailment of the wagon, with the risk of collision, injury or loss of life.
Safety advice:	The RAIB is now carrying out an investigation into the circumstances of the derailment. This will include a detailed assessment of how the interaction between the track and the freight vehicle at Primrose Hill led to derailment. It will include a review of the condition of the track, its inspection and maintenance, and the standards related to the detection and rectification of track twist. In the interim, this USA is being issued by the RAIB to alert operators and owners of FEA wagons to the circumstances of the derailment, its likely immediate causes and its similarity to the Duddeston Junction incident. On the basis of this and previous derailments, the RAIB remains concerned about the issue of unbalanced loading on FEA wagons and advises operators of such wagons to re-assess the associated risk of derailment, and to implement suitable mitigation measures. In doing so, FEA wagon operators should urgently consider: • restrictions on the maximum weight of a 20 foot container carried on the same vehicle as an empty or lightly laden 40 foot container to allow for lateral offsets in payload that may reasonably be encountered; and/or • applying any other restrictions that may be necessary to mitigate the risk of excessively unbalanced loads.

USA Sign-off*			
Inspector Name:		**DCI Name:**	
Inspector Signature:		**DCI Signature:**	
Date:	06 November 2013	**Date**	06 November 2013

Appendix I - Greenbrier specification drawing for the FEA(E) wagon



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