RAIB
Rail Accident Investigation Branch

Rail Accident Report

Container train accident near Althorpe Park, Northamptonshire
18 July 2011

Department for Transport

Report 17/2012
August 2012

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
The Wharf
Stores Road
Derby UK
DE21 4BA

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

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Container train accident near Althorpe Park, Northamptonshire, 18 July 2011

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Summary

At 17:52 hrs on 18 July 2011, a partially detached metal panel on a container train struck the cab of a passing track maintenance vehicle, smashing the side window. The driver of the maintenance vehicle subsequently reported seeing a similar panel on the trackside, one mile further on. No-one was injured.

The panels, approximately 2.5 m high by 1.0 m wide, were from two modified freight containers, which were fitted with power-generation equipment and were being exported overseas. The panels had covered two ventilation apertures in the container sides. They had been fitted as a temporary measure to help prevent water ingress during the sea voyage.

The cause of the accident was that screws securing the panels became loose during rail transit. This was initiated by a loss of the clamping force in the bolted joint because of the mechanical properties of a foam seal that was fitted.

The manufacturer had ensured that the containers were approved in accordance with the International Convention for Safe Containers (the regulatory regime used for assuring the structural safety of freight containers used internationally and transported by surface means). However, neither the convention nor the manufacturer required a structural assessment of this bolted joint.

The operational safeguards used to prevent unsuitable freight containers being carried on the railway relied on visual examination, and were therefore unable to identify the hidden structural defect.

The RAIB has made three recommendations to the Heath and Safety Executive. They are concerned with:

- making the relevant freight container manufacturers, repairers, modifiers, users and approval bodies aware of the need to assess the structural integrity of such attachments; and
- an amendment of the International Convention for Safe Containers.

The RAIB has also made a recommendation to the train operator regarding its processes for assuring the structural integrity of freight containers that it carries on the railway.

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.

2 The RAIB does not establish blame or liability, or carry out prosecutions.

Key definitions

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

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

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

The accident

Summary of the accident

6 At 17:52 hrs on 18 July 2011, a partially detached metal panel on train 4L68 struck the cab of train 6J02 as the trains passed each other near Althorpe Park, Northamptonshire (figure 1). Train 4L68 was the 12:15 hrs container service from Birch Coppice (near Tamworth) to Felixstowe docks. It was travelling on the *up* Northampton line. Train 6J02 was a *tamper*. It was on the adjacent *down* Northampton line.

7 After the accident, the tamper driver reported seeing a similar panel in the up *cess* one mile further on. The two panels were from two containers on train 4L68, which housed power-generation equipment (the containers are also referred to in the report as power-generation units). No-one was injured, but there was the potential for more serious consequences; people on station platforms and railway staff working on the track were particularly at risk.

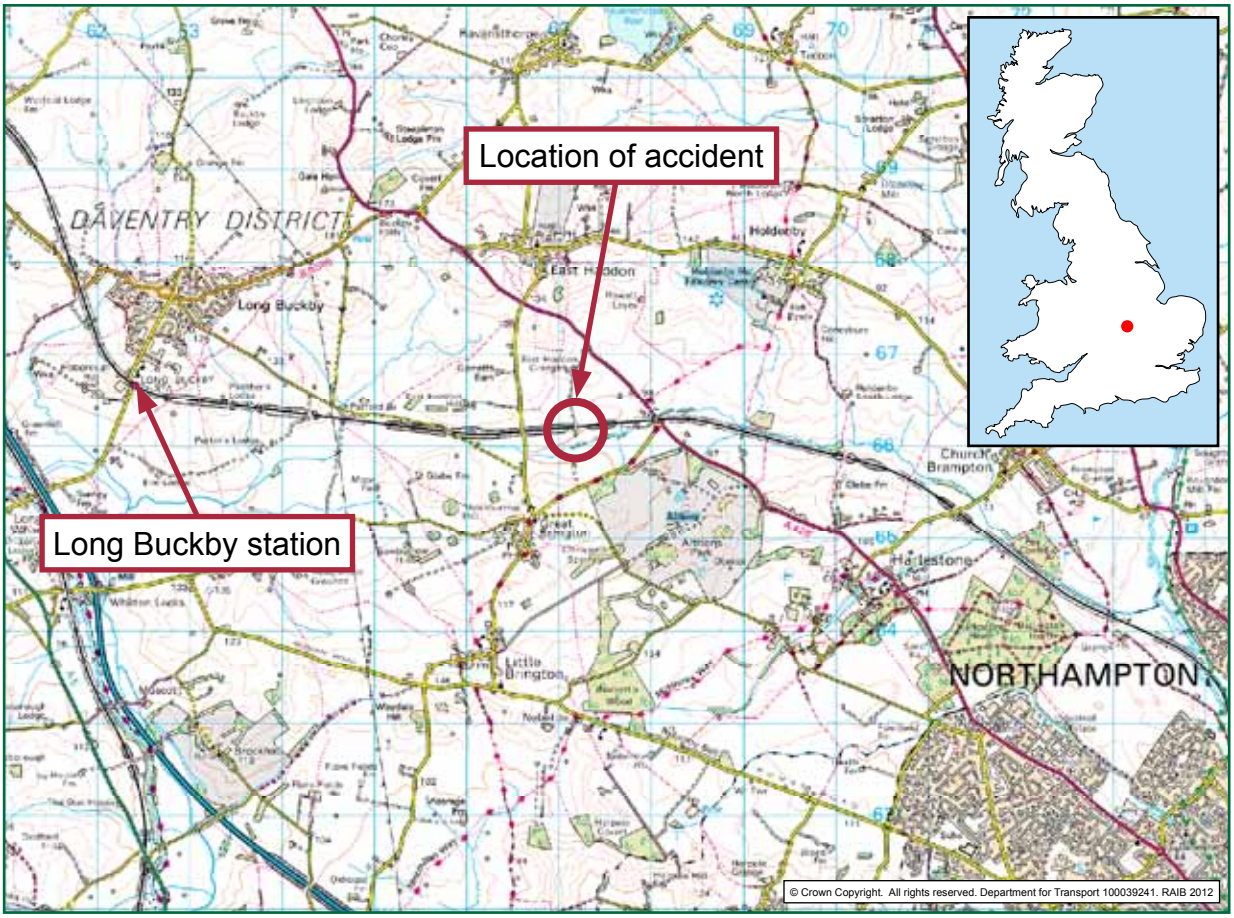

Figure 1: Extract from Ordnance Survey map showing location of accident

Context

Location

8 Althorpe Park[1], the location of a former station, is on the section of the *West Coast Main Line* that runs between Rugby and Northampton, figure 2. The railway comprises two lines: the up Northampton (towards Northampton and London) and the down Northampton (towards Rugby and Birmingham). It is electrified with a 25kV AC overhead power supply; the signals are controlled from the Rugby *power signal box*.

9 The collision occurred close to the 73½ *milepost*, around two miles east of Long Buckby station (75 miles 37 chains).

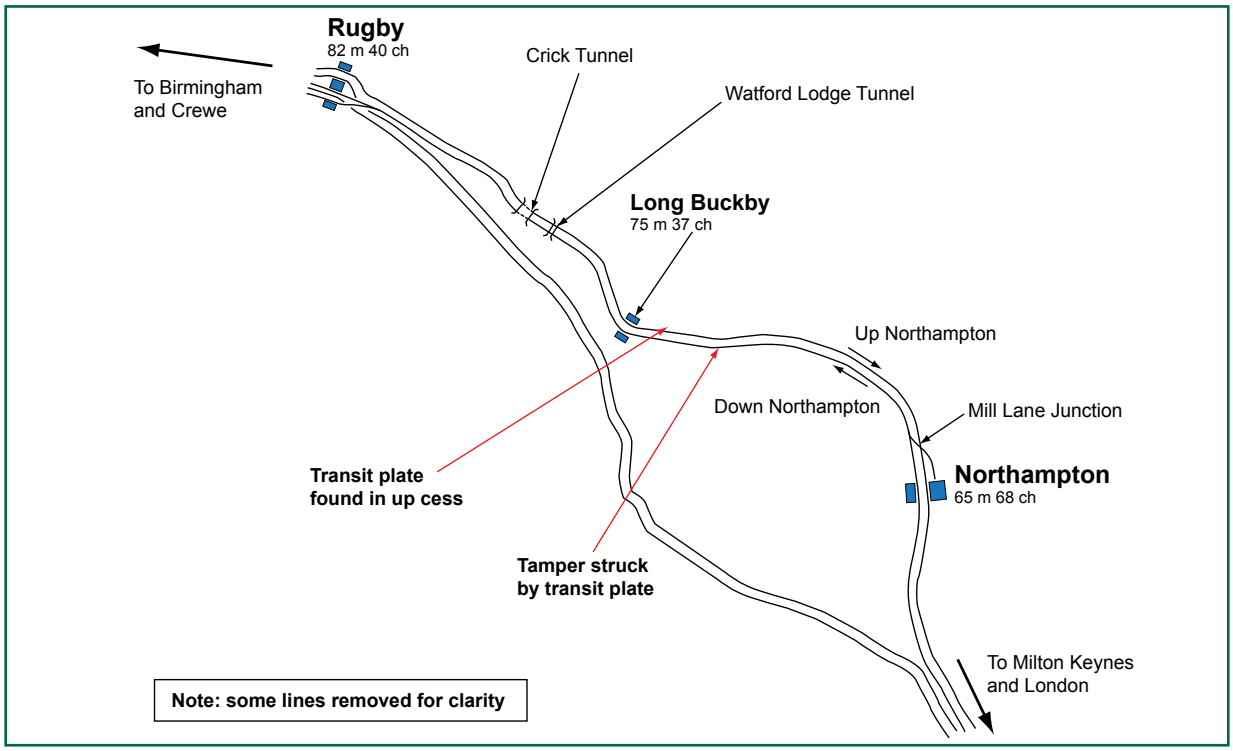

Figure 2: Diagram of the railway between Rugby and Northampton

Organisations involved

10 Broadcrown, a designer and manufacturer of power-generation units, owned and assembled the containers and their contents. It contracted LV Shipping, a *freight forwarder*, to make the arrangements for them to be exported to Venezuela.

11 Maersk Line was the *container carrier* contracted by LV Shipping to collect the containers from Broadcrown's works in Staffordshire and ship them to Venezuela. Maersk Line subcontracted Freightliner, a railway *freight operating company*, to provide rail carriage from an *inter-modal freight terminal* near Tamworth, Birmingham (BIFT), via Felixstowe, to the UK departure port, Tilbury.

12 Roadways Container Logistics (Roadways) operates BIFT. It loaded, prepared and checked train 4L68 before departure. The staff who did this were employed by Roadways, had been trained by Freightliner, and were working to Freightliner operational procedures.

[1] 'Althorpe Park' is the name used for the closest defined railway location to where the accident occurred. It is immediately north of the Althorp Estate, near Northampton.

13 Colas Rail operated the tamper that was struck by the detached panel, and employed the tamper driver.

14 Network Rail owns and maintains the railway infrastructure where the accident occurred. It also operates the signalling equipment.

15 Broadcrown, LV Shipping, Maersk Line, Freightliner, Roadways, Colas Rail and Network Rail freely co-operated with the investigation.

Trains involved

16 Train 4L68 comprised a class 66 diesel electric locomotive and 24 container flat wagons. One of the power-generation unit containers was loaded on the leading end of wagon 8; the other, on the trailing end of wagon 9. Both wagons were FSA-type wagons. The containers had ISO identification marks[2], CPIU 9006609 and CPIU 9006580.

17 Figure 3 shows key aspects of the train configuration and position of the containers.

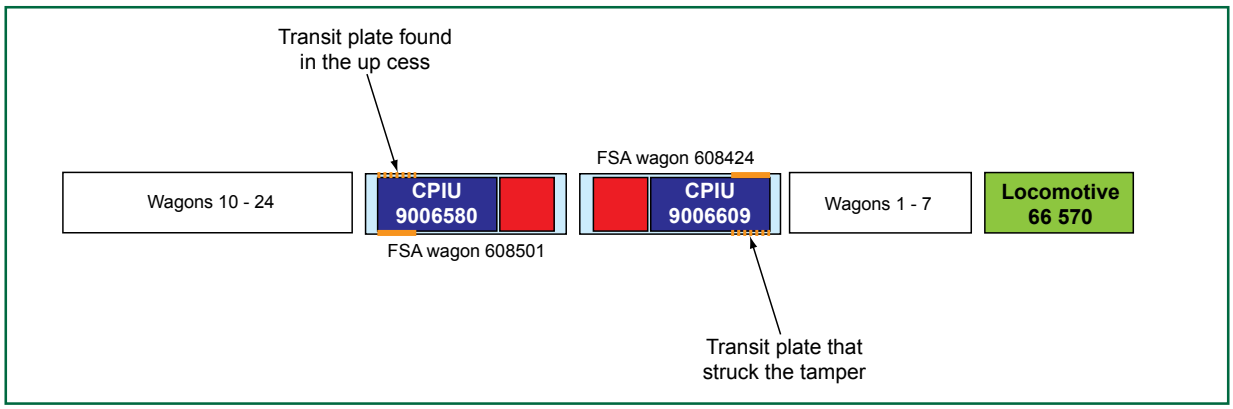

Figure 3: Configuration of train 4L68

18 Train 6J02 was a self-propelled tamper designed for maintaining track geometry in the areas of *switches and crossings*. It was travelling from a yard in Watford to Rugby.

Power-generation units

19 The power-generation units were for use as standby electrical power supplies. Modified general-purpose freight containers, 40 foot long by 9 foot 6 inches high, were used as enclosures for the diesel-operated power-generation equipment.

20 Broadcrown purchased the freight containers from a specialist container company. The purchase order required the supplier to source two containers and to modify them to requirements that Broadcrown prescribed. This principally involved adding various apertures, doors, equipment fixing points, and ventilation-related equipment; structural integrity was to be assured through compliance with international regulations.

21 Two of the apertures, one in each container side, were to allow the necessary airflow into the enclosure when the power-generation equipment was running. These side ventilation apertures were fitted with open horizontal louvres (figure 4).

[2] The *International Organization for Standardization* (ISO) issues a number of international standards for freight containers. It includes the requirement for each container to carry a unique identification mark in accordance with ISO 6346:1995 'Freight containers – Coding, identification and marking'.

Figure 4: Container CPIU 9006580 showing the location of the side ventilation aperture

22 Because of concerns about water ingress during the sea voyage, Broadcrown decided to fit 1.7 mm thick galvanised steel panels, approximately 2.5 m high by 1.0 m wide, over each aperture. It called these 'transit plates', as they were only required to protect the power-generation equipment during shipping, and were to be removed before the equipment was operated. Two of these transit plates were the panels that detached from train 4L68 (paragraph 7).

23 The transit plates were fixed to the container side by two vertical columns of five near-equally-spaced bolted joints[3], each comprising an *M8* stainless steel screw screwed into a *threaded insert*. Figure 5 shows a diagram of the arrangement, and also a photograph of a plate that remained attached. The threaded inserts, essentially threaded metal tubes, were secured into holes in the container sidewall by a special tool. This tool was used to pull the far end of the tube and *cold form* it tight against the rear surface of the container sidewall (figure 6). The screws had a button head with a special hexagonal socket to make them resistant to tampering (figure 6 inset). To improve sealing, a 50 mm wide strip of 6 mm thick polyethylene foam was fixed around the perimeter of the plate. Tightening the screws made the transit plates compress the foam against the container side.

External circumstances

24 When train 4L68 passed close by at around 16:00 hrs, Network Rail's weather station near Coventry recorded a west-southwest wind of speed 14.7 km/h, with no gusting. At the time of the accident, the recorded wind was from the west, with a speed of 16.6 km/h; again there was no gusting.

25 The local temperature was around 17 ºC. It was not raining.

[3] 'Bolted joint' is a term used in the report to describe the mechanical connection of two or more parts by threaded fasteners.

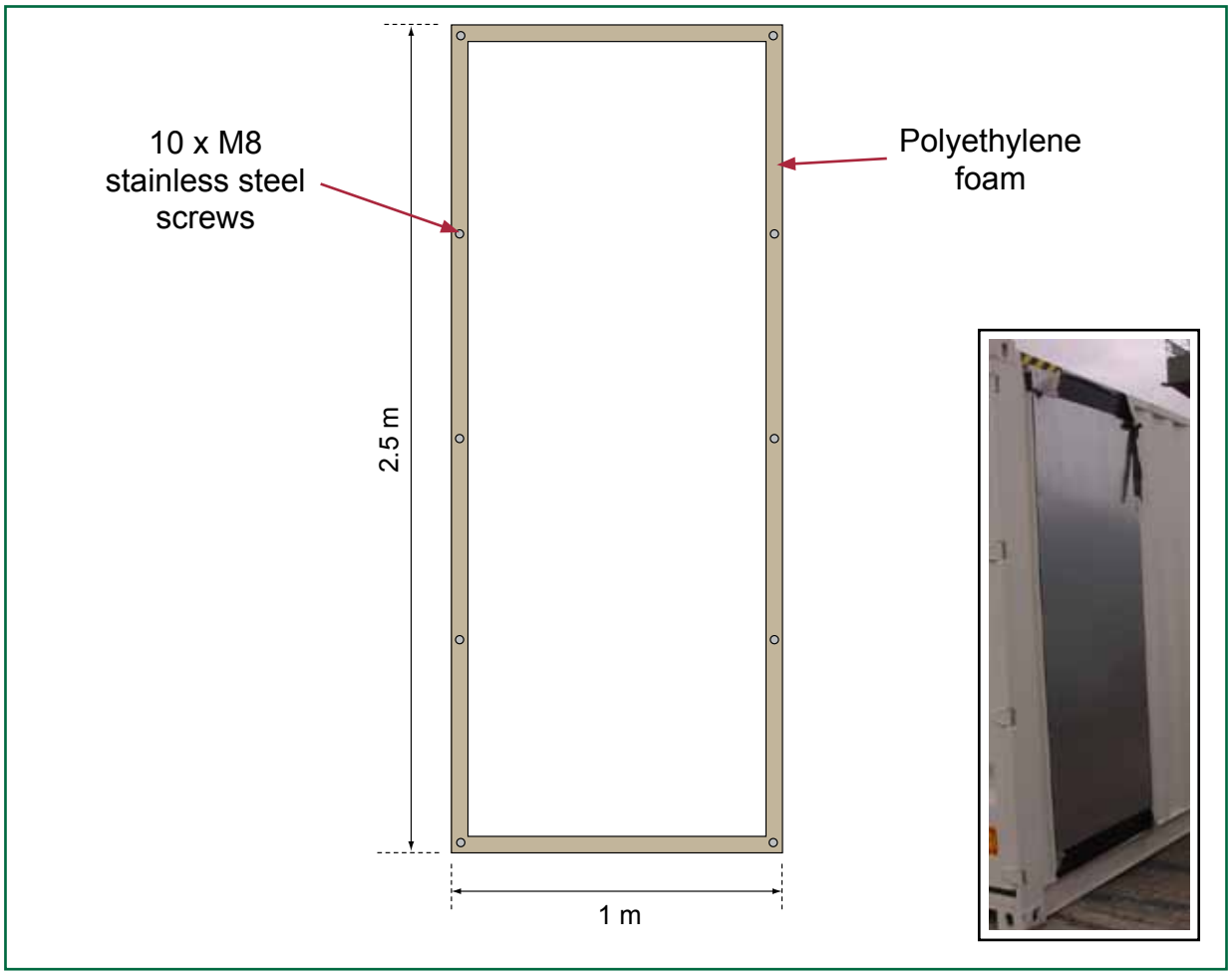

Figure 5: Transit plate attachment arrangement. Inset shows the transit plate that remained attached to container CPIU 9006609 (the black adhesive tape was applied after the accident)

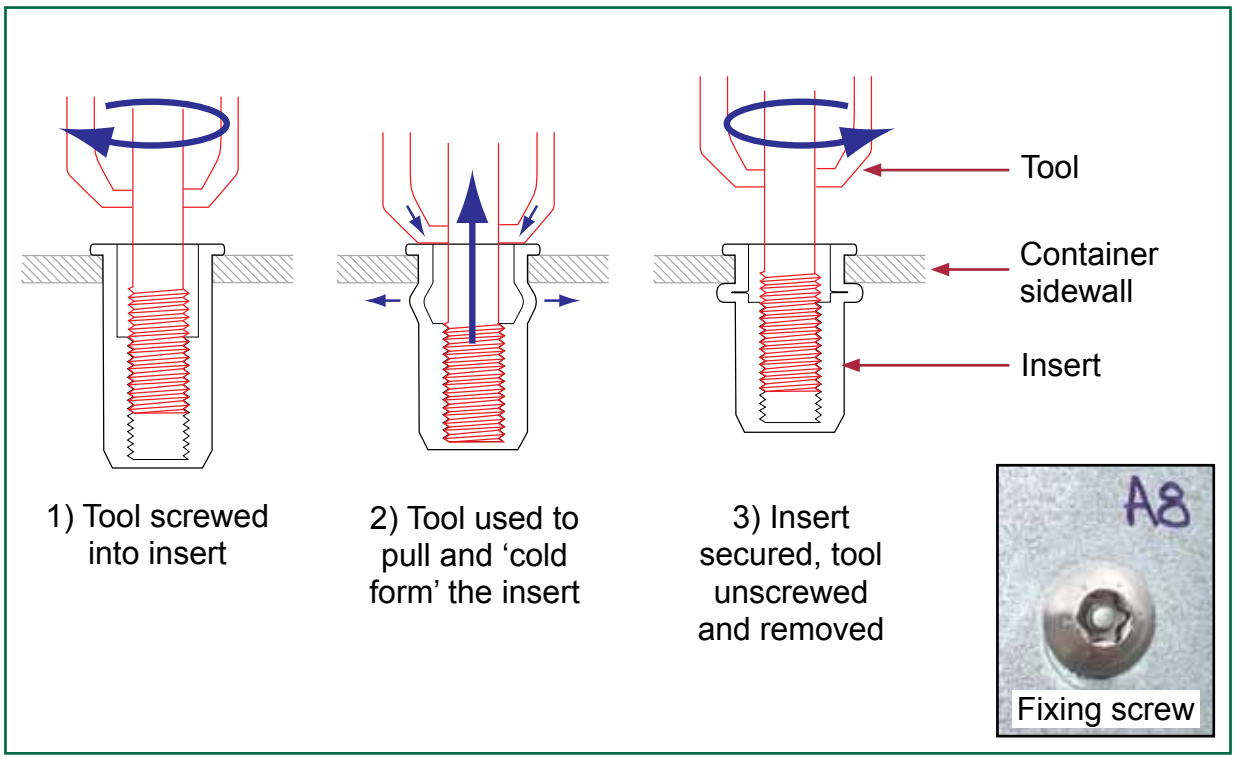

Figure 6: Threded insert and fixing screw used to secure the transit plate

Events preceding the accident

26 On Friday 15 July 2011, a road haulage company, subcontracted to Maersk Line, collected the two containers from Broadcrown's works and took them to BIFT. The two drivers signed paperwork to say the containers were 'received in good condition'. Roadways recorded nothing untoward regarding the condition of the containers when they arrived at BIFT.

27 Roadways kept the containers at BIFT over the weekend and loaded them on to train 4L68 on Monday morning, 18 July 2011. The train preparation staff placed container CPIU 9006609 against the leading *headstock* of wagon 8, with a smaller container behind, and container CPIU 9006580 against the trailing headstock of wagon 9, with another smaller container in front (see figure 3). This was in accordance with standard practice, and intended to prevent the container end doors opening, or being opened, during transit. At around 11:00 hrs, with all the containers loaded, the shift supervisor carried out his *pre-departure examination*, walking around the train to confirm there was nothing untoward. There were no weather conditions at the time that affected this.

28 Part of the pre-departure examination includes checking for container defects[4]. The shift supervisor stated that he specifically remembered seeing both transit plates and side personnel doors on the containers and, from what he could tell, considered them to be securely attached. He signed the *train document* and the *certificate of readiness* for the driver of train 4L68 that confirmed that the train had been prepared and checked in accordance with Railway Group standards and Freightliner procedures.

29 Train 4L68 departed from BIFT at 12:20 hrs. Footage from a closed circuit television (CCTV) camera at BIFT showed that the transit plates were in place as it left (figure 7).

30 On its journey to Rugby station, train 4L68 passed 22 other trains and went through two tunnels: Park Street (Walsall) and Beechwood. At Rugby it spent just over an hour in a *goods loop*. Figure 8 shows the route the train took to Rugby, and then to Althorpe Park.

Events during the accident

31 Train 4L68 left Rugby at 17:35 hrs, and was routed onto the up Northampton line. Shortly afterwards, passenger train 2Y21 passed by train 4L68 on the right-hand side. Train 4L68 then went through two tunnels, Crick, 595 yards (544 m) and, shortly afterwards, Watford Lodge 115 yards (105 m). At 17:48 hrs, train 4L68 was passed by another passenger train, 1S96, again on the right-hand side.

32 By 17:50 hrs train 4L68 was running through Long Buckby station, travelling at around 60 mph (97 km/h). The RAIB estimates that, on the basis of where it was found, the first transit plate detached and fell into the cess around a minute later.

[4] Freightliner document PSD/0300 issue 4 detailed the pre-departure checks required at the time of the accident – see paragraph 98.

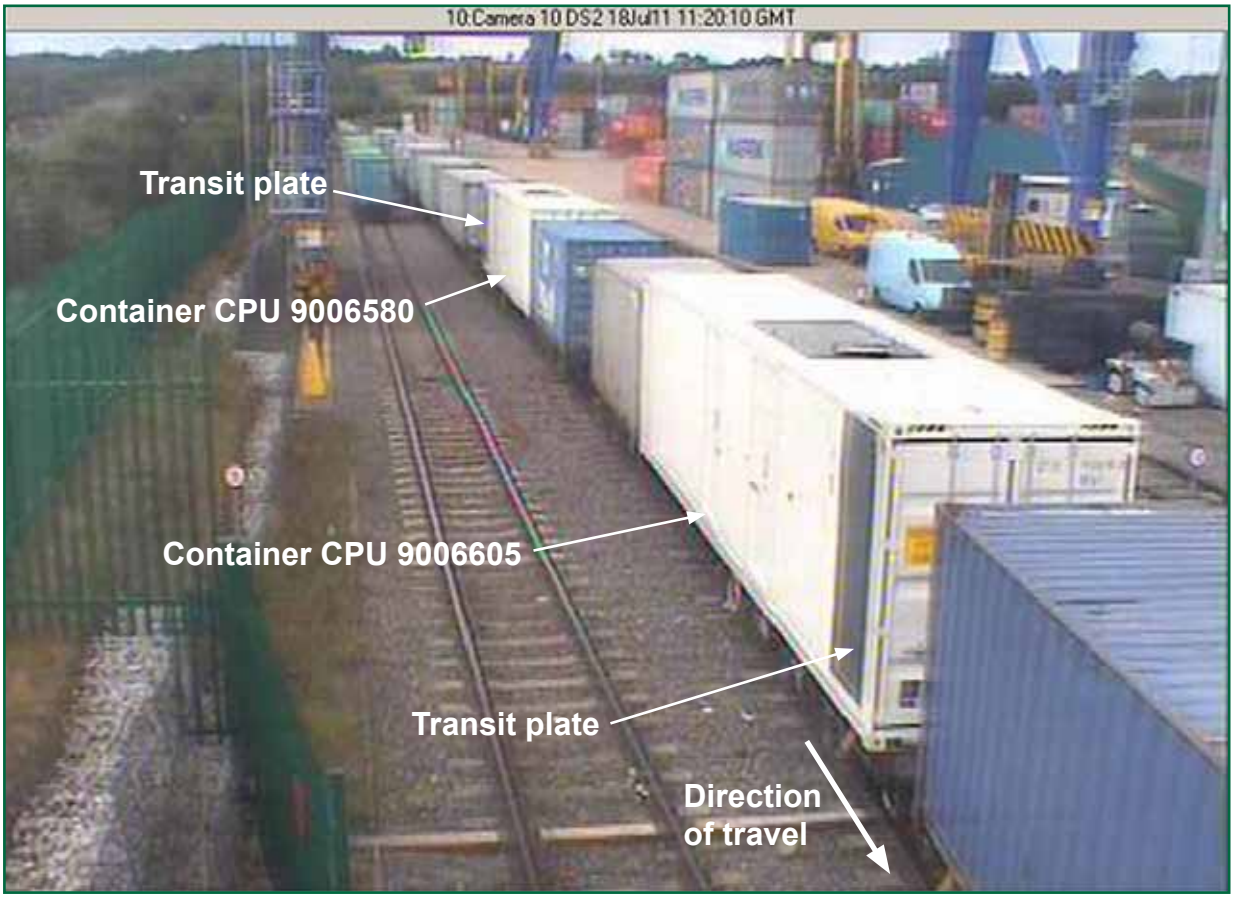

Figure 7: CCTV image of the right-hand (six-foot) side of train 4L68 departing BIFT (image courtesy of Roadways)

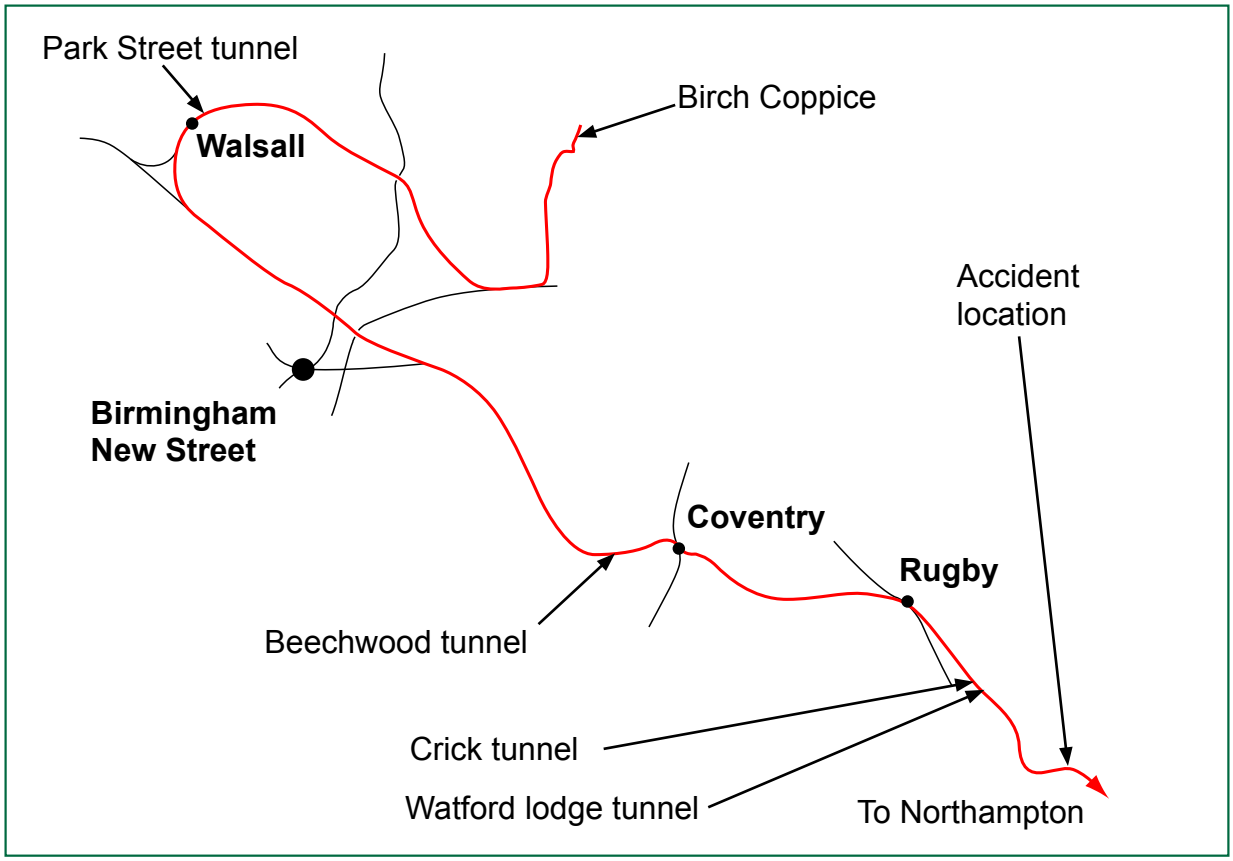

Figure 8: Route of train 4L68

33 The driver of the tamper (train 6J02) saw metal flapping at his head height on the side of train 4L68 as he approached it on the down Northampton line. He was travelling at between 56 and 58 mph (90 and 93 km/h). He managed to get to the floor before the metal struck his driving cab. In so doing, he released the controls and as a result the brakes automatically applied and brought the tamper to a stand.

Events following the accident

34 At 17:55 hrs, the tamper driver made an emergency call to Rugby power signal box and requested that all trains on the up Northampton line were stopped. The signaller brought train 4L68 to a stand by setting signal RY1062, which is around four miles east of Long Buckby station, to red. He instructed the driver to examine his train. The driver called back at 18:25 hrs and advised that his train was intact and that there was no evidence of anything having fallen from it. He then took the train forward to Felixstowe.

35 The tamper driver was uninjured, but his cab was damaged by the impact and the side window was smashed (figure 9). The impact also caused some damage to other parts of the tamper. After starting to drive the tamper forward to Rugby, he stopped again to report that there was debris in the up Northampton cess that looked similar to the metal that had earlier struck his machine.

36 Train 4L68 arrived at Freightliner's Felixstowe terminal at 01:05 hrs on 19 July 2011.

Figure 9: Damage done to the driving cab of the tamper (photograph courtesy of Colas Rail)

37 A member of Freightliner's ground staff examined the train when it arrived. He found that the transit plate on the right-hand side of container CPIU 9006580 was loosely attached and flapping. He also found that there was no transit plate on the left-hand side. On container CPIU 9006609 he found that the transit plate was in place on the left-hand side, but with missing screws, and that there was no transit plate on the right-hand side.

Recent related freight container incidents

38 At around 20:40 hrs on 18 August 2009, the driver of a passenger train reported that an object protruding from a passing container train near Carluke, South Lanarkshire, had struck his train. The driver of the container train was stopped near Carstairs, where he found a piece of aluminium cladding had detached from a *tank container* and was hanging off. The RAIB investigated the incident and published a bulletin[5]. The cladding had become loose because a strap, used to retain it, was missing. One of the possible causes of the loss of the strap was the failure of its fixing arrangement (a combination of screws and rivets). The RAIB identified eight other incidents relating to loose or missing straps on tanks between December 1999 and July 2009, and highlighted the need for tank owners to review the integrity of such retention arrangements and associated systems for maintenance and inspection.

39 Toward the end of 2010, a road haulage contractor reported the detachment of transit plates on another container that it had collected from Broadcrown's works. Broadcrown sent fitters to the haulier's depot to secure the plates for onward travel. The transit plates had also been fitted to cover large apertures in the container sides. Those involved recalled that the plates were a different design to the transit plates on containers CPIU 9006580 and 9006609, and were of the opinion that the plates detached because the container flexed during lifting. There are no records or photographs of the detached plates, or the repairs that Broadcrown made.

40 At 10:35 hrs on 11 April 2011, the driver of a passenger train reported an open container side door on a train waiting in Waller's Ash loop, near Winchester. CCTV evidence showed that the door was closed when the train had earlier passed Shawford station; it had therefore opened while the train was moving. Although there was no evidence of impact or injury, the open door presented a risk to station users and passing trains. The freight container was being delivered to another UK manufacturer of power-generation units for use as an enclosure. The side door was for equipment access, and the catch on it had recently been damaged.

41 At 16:02 hrs on 8 March 2012, a Freightliner train was brought to a stand at Mill Lane Junction, just outside Northampton station, after someone in the station reported that a panel on a container roof was 'flapping'. Removal of the panel, so that the train could safely continue its journey, required isolation of the overhead power supply. No other damage or injury was reported. The panel had been riveted to the roof as part of repair work undertaken at Felixstowe docks. This incident is currently being investigated by Freightliner. The apparent inadequacy of the fixing arrangement has been considered in making recommendations in this report.

[5] Bulletin 04/2010, available at www.raib.gov.uk.

The investigation

Sources of evidence

42 The following sources of evidence were used:

- examination of the containers, the detached transit plates and fasteners;
- a structural assessment, commissioned by the RAIB, of the bolted joint configuration used to secure the transit plates;
- CCTV records from BIFT and Felixstowe port;
- train and signalling operation records;
- railway industry control logs;
- photographs taken by the industry parties, before and after the accident;
- first accounts of railway staff directly involved;
- witness statements;
- regulations and standards relating to the design, approval and modification of freight containers, such as those published by the *International Maritime Organization* (IMO) and the ISO; and
- railway industry standards relating to freight operations and the structural design of railway freight wagons.

Key facts and analysis

Background information

International requirements for freight containers

International Convention for Safe Containers

43 The International Convention for Safe Containers,1972 (CSC)[6], is published by the IMO. It has two goals:

- '…to maintain a high level of safety of human life in the transport and handling of containers by providing generally acceptable test procedures and related strength requirements…'; and
- '…to facilitate the international transport of containers by providing uniform international safety regulation...'.

The CSC came into force in the UK in 1977. A number of amendments have been made since.

44 The CSC applies to the majority of freight containers used internationally, whether transported by sea, waterway, road or rail. It defines structural safety requirements, and requires that every new container is approved in accordance with them. It also requires that, once approval has been granted, the owner maintains the container in a safe condition and subjects it to an examination scheme.

45 The Administrations of Contacting States (national governments) are responsible for establishing procedures for container approval and examination compliant with the criteria in the CSC. However, a government is able to entrust this responsibility to an authorised organisation – for instance a *classification society*. A government has to notify the IMO of the organisations it has authorised, so information can be shared with other national governments.

46 In Great Britain, the Freight Containers (Safety Convention) Regulations 1984 make the *Health and Safety Executive* (HSE) responsible for the approval of containers and the schemes for their ongoing examination. The HSE has published two supporting documents[7]; one details the arrangements for container approval (including eligibility for appointment as an authorised organisation) and the other, the conditions for approval of examination schemes.

47 Each approved container is required to have a *safety approval plate* 'permanently affixed' in a 'readily visible place'. As well as showing information relating to the container's strength and load rating, the plate details:

- country of approval, and the approval reference;
- date of manufacture, and the manufacturer's identification number; and
- information relating to the examination scheme to which the container is subjected.

Figure 10 shows the safety approval plate fixed to container CPIU 900609.

[6] ISBN 978-92-801-1411-9.

[7] These documents, 'Approval of containers' and 'Freight Containers (Safety Convention) Regulations 1984 - conditions for approval of examinations schemes or programmes', are available at www.hse.gov.uk.

Figure 10: Safety approval plate fixed to container CPIU 9006609. The RAIB understand that the white decal, entitled 'Re-manufacturing date 05/2011', was affixed when the container was modified (paragraph 20). Note: Recognised by the CSC as acceptable practice, the safety approval plate has been grouped with other official plates on one base plate

48 Annex II of the CSC defines the set of test loads and test procedures to be carried out when approving a container. The tests are designed to verify container structural integrity.

49 As well as maintaining a container in a safe condition, the owner is responsible for ensuring that any modifications he makes do not 'adversely affect or render inaccurate' the information on the safety approval plate. If modifications result in structural changes then the owner is required to notify the relevant national government, or a duly authorised organisation, so that they can determine whether retesting is necessary prior to recertification. If the owner does not follow this procedure, he must remove the safety approval plate from the modified container.

ISO standards for freight containers

50 Containers CPIU 9006609 and 9006580 were classified as general purpose ISO Series 1 freight containers. ISO 1496-1, 'Series 1 freight containers - Specification and testing - Part 1: General cargo containers for general purposes', defines the basic specification and test requirements for such containers. It covers design aspects, including: dimensions, load rating, corner fittings[8] and identification markings. A significant part of the document, however, is concerned with structural integrity. It specifies a number of related requirements including a set of test loads and test procedures similar to those in the CSC.

UIC standards for freight containers

51 *International Union of Railways* (UIC) standard UIC 592-2, 'Large containers for transport on wagons – Technical conditions to be fulfilled by large containers accepted for use in international traffic', specifies a number of requirements relating to freight containers carried by rail, addressing similar aspects to those covered in ISO 1496-1. As ISO 1496-1, it specifies structural test loads and procedures that are similar to those in the CSC.

Arrangements for the manufacture of the power-generation units

52 Broadcrown issued the purchase order for the two modified freight containers (paragraph 20) on 25 May 2011. It required the modified containers to be 'CSC plated' to show that they were approved to CSC rules. This was so that Broadcrown could export the power-generation units using a standard freight container shipping service. The purchase order made no reference to transit plates, or their future fitment.

53 On 8 July 2011, a surveyor working for an approved classification society issued the container supplier a certificate, entitled 'Attestation of Conformity,' for each modified container. The certificates state that, according to the CSC, the containers were 'able to transport …general cargo' up to a defined maximum gross weight. The RAIB understand that this effectively recertified them as approved containers. The original safety approval plates were left attached (paragraph 49 and figure 10).

54 In early July, when the power-generation equipment had been fitted at its works in Staffordshire, Broadcrown instructed two of its fitters to install the four transit plates, one on each container side (paragraph 22). The fitters drilled all the holes, and fitted the threaded inserts and M8 screws (paragraph 23). They recalled tightening the screws with a socket and hand ratchet. There were neither design drawings to show how the transit plates were supposed to be attached, nor any documented assembly instructions for the fitters to follow.

[8] Series 1 containers are equipped with special fittings at each corner, top and bottom, to facilitate loading, securing, lifting and stacking.

55 Also in early July, Maersk Line confirmed the transport booking and, via LV Shipping, requested that Broadcrown completed forms to certify that the containers carried a safety approval plate and had been examined in accordance with CSC requirements. Broadcrown signed these on 14 July 2011.

Examination of the transit panels and the bolted joints used to secure them

56 Following the accident, the RAIB examined containers CPIU 9006580 and 9006609 and the transit plates that detached. This confirmed that:

- the plate that struck the tamper was from CPIU 9006609 (figures 3 and 11a); and
- the plate that the tamper driver later saw in the up cess was from CPIU 9006580 (figures 3 and 11b).

57 Figure 12 shows the bolted joint configuration that was used on container CPIU 9006609. The joint used on CPIU 9006580 was similar, except that Broadcrown fitted a single steel washer between the underside of the screw head and the transit plate.

58 As there were no design drawings (paragraph 54), the dimensions shown in figure 12 have been derived from measurements and component datasheets.

59 Figure 12 represents the condition just after screw tightening. The RAIB found evidence of light score marks around some of the fixing holes on the transit plates to indicate that the screws had been tightened. However, it is not possible to be certain of the extent of tightening since torque values were neither prescribed nor measured. The range of the dimensions shown and the degree of compression of the polyethylene foam, which ultimately affect the degree of screw engagement in the threaded insert, are due to this lack of certainty.

Identification of the immediate cause[9]

60 **The immediate cause of the accident was that screws, which were securing the transit plate on the right-hand side of container CPIU 9006609, came loose enabling the upper part of the transit plate to detach and, because of its flexibility, infringe the path of the approaching tamper.**

61 The following evidence supports this:

- the six uppermost screws used to secure the transit plate were missing when the RAIB examined the container after the accident;
- the six uppermost threaded inserts remained in place and in good condition; there were no broken screw parts in any of them; and
- the distressed state of the lower screws, and their threaded inserts, and the evidence of pull-through distortion around the lower holes on the transit plate.

62 The above evidence is consistent with the tamper driver's account of the upper part of the transit plate 'flapping' as he approached train 4L68 (paragraph 33). It was then torn from the lower screws in the impact.

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

Figure 11: The transit plates that detached from containers CPIU 9006580 and 9006609 on train 4L68

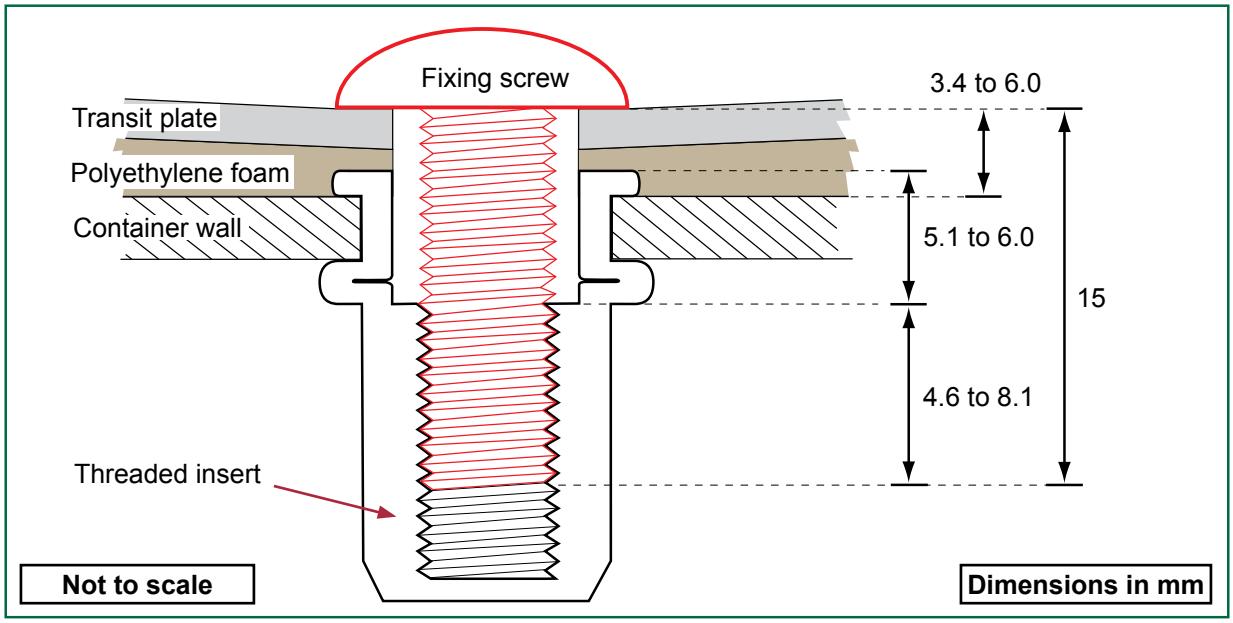

Figure 12: Cross-section through a typical bolted joint used on CPIU 9006609

Identification of causal[10] and underlying factors[11]

Structural integrity of the bolted joints

63 **The loosening of the screws securing the transit plate was initiated by a loss of *preload* in the bolted joints as a result of continued compression of the polyethylene foam after tightening. This was a causal factor.**

64 The RAIB commissioned a structural assessment of the bolted joint configuration. This identified that the screw loosening mechanism is most likely to have been a two-fold process involving:

- a loss of preload in the bolted joint as a result of the polyethylene foam continuing to deform after the screws were tightened; followed by
- slip, between the transit plate and the screw head, due to external loads that the transit plates were then subject to during handling and transportation.

65 Preload is required in a bolted joint to provide the clamping force needed to hold the mating surfaces together. It is generated when a joint is tightened. Any subsequent loss of preload directly reduces the clamping force and risks external loads being able to loosen the threaded components.

66 Soft sealing materials can continue to deform after they are first compressed. In bolted joints, this risks preload losses occurring soon after the joint is tightened. The polyethylene foam used for sealing the transit plates (paragraph 23) exhibited such behaviour. Laboratory tests showed that, by the time the containers were loaded on to train 4L68, the clamping force holding the plates in place is likely to have been less than half of that when the screws were first tightened[12].

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

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

[12] The RAIB observed that there was no control regarding the degree to which the screws were originally tightened (paragraph 59).

67 While this loss of preload is itself unlikely to have directly led to the loss of the screws, it would have left the screws in a condition where they were prone to self-loosening under foreseeable external loads. The self-loosening that then occurred was most probably due to a combination of two effects:

- Distortion of the container side ventilation apertures during lifting: this would have resulted in relative transverse movement between the container side and the transit plate, and therefore slip between the plate and the underside of the screw head that, when repeated each time the container was loaded or handled, was capable of driving self-loosening.
- Aerodynamic loads during the rail journey: these would result in flexing of the transit plates, as they are drawn off the container sides, and therefore also slip capable of driving self-loosening. Vibration during travel could have a similar effect.

68 The structural assessment of the bolted joint established that, based on defined in-service railway loads[13], the screws and threaded inserts were strong enough not to have failed as a result of overload, fatigue or thread stripping. The as-examined condition of the uppermost threaded inserts on the right-hand side of container CPIU 9006609, and the lack of evidence of any fractured screw parts (paragraph 61), further confirms that such failure mechanisms did not lead to the detachment.

69 Despite the lack of assembly instruction or guidance, the light scoring found around some of the fixing holes is evidence that the screws were initially tightened (paragraph 59). Furthermore, given the difficult access to the uppermost screws after leaving BIFT[14], and their tamperproof design, deliberate undoing is unlikely.

In-house design and assessment of the bolted joints

70 **Broadcrown did not require that the bolted joints were designed or assessed against an external load criterion, or consider their possible failure mechanisms. This was a causal factor.**

71 Broadcrown fitted the transit plates in final assembly. It entrusted experienced fitters and their supervisors to decide what they were to do and the components they needed. They used a configuration of transit plate and fasteners that Broadcrown had used when previously shipping containers.

72 Broadcrown's engineering department was neither involved in the specification of the transit plates, nor undertook an assessment of the bolted joints used to attach them. Broadcrown was aware of the need to ensure the structural adequacy of the modified containers for use as enclosures for power-generation equipment. It is for this reason that it required that containers CPIU 9006580 and 9006609 were supplied with a valid CSC plate. However, it saw the transit plates as temporary measures to protect the power-generation equipment while the containers were at sea (paragraph 22). As a result, Broadcrown considered that the plates were neither part of, nor affected, the primary container structure, and therefore did not warrant detailed assessment.

[13] Considering aerodynamic and inertial loads in Railway Group standard GM/RT 2100 issue 4.

[14] The upper screws were nearly 4 metres above ground level. Special equipment would have been required for access to them. Train 4L68 spent no significant time waiting in a station platform.

73 The RAIB found no structural requirement in the CSC that is relevant to the transit plates or their attachment (this is discussed further in paragraphs 77 to 83). The reliance on a regulatory structural assurance regime that excluded test loads relevant to the detachment of the transit plates was a probable underlying factor.

74 The RAIB found no evidence that the specialist container company, which Broadcrown contracted to supply the CSC-plated containers, was aware of the need for the transit plates or of the intention to fit them (paragraph 52)[15]. Even if it had been, it is unlikely it would have undertaken an assessment of the bolted joint since the CSC did not require it.

75 The RAIB found no evidence that a previous detachment incident (paragraph 39) had led to a change of policy regarding the need to assess the integrity of such bolted joints. Although it involved a transit plate of a different design, had the cause of this earlier detachment been investigated, and a change made, then the accident near Althorpe Park may not have occurred. Broadcrown's response to previous related incidents was a possible factor.

Independent assessment of the bolted joints

76 **The bolted joints were not independently assessed and no external requirement was found for this. This was a causal factor**.

77 The requirements for *inter-modal* freight containers are highly specified, and include the need for an independent structural assessment before a container can be used in service. The RAIB examined the following key documents to understand their requirements:

- the CSC (paragraphs 43 to 48);
- ISO 1496-1 (paragraph 50); and
- UIC 592-2 (paragraph 51).

It also reviewed whether any railway industry standards contained relevant requirements.

78 In summary, no evidence was found of any specific external requirement that is applicable to the external loading of structures attached to the exterior of freight containers. There was therefore no requirement for the bolted joints securing the transit plates to have been independently assessed before the containers were used.

The CSC

79 The CSC requires that national governments, or a delegated organisation that they have authorised, approve all new international freight containers (paragraphs 44 and 46). Approval can be by design type (in which case approval can be obtained for a series of essentially identical containers) or on an individual basis.

[15] The supporting HSE document, 'Approval of containers' (paragraph 46), requires that where an owner wishes 'to make a modification to a container which could affect safety, he shall apply to the authorised organisation which granted (the CSC) approval.' The RAIB found no evidence that Broadcrown considered that the addition of the transit plates affected safety in a manner that made this necessary.

80 CSC approval gives assurance of a container's structural integrity. To be granted, the container (or a similar one of the same design) must be capable of withstanding seven defined test loads[16]. In the main they relate to a freight container's ability to withstand loads associated with lifting, stacking, securing and payload containment.

81 The most potentially relevant are test load 1 ('lifting test') and test load 7 ('side-walls'). As discussed in paragraph 67, repeated lifting could have contributed to screw self-loosening. However, a single lift, which is all that test load 1 requires, is unlikely to have resulted in visible signs of joint failure; the containers were lifted several times prior to train departure without the transit plates detaching. Test load 7 only considers the effect of internal loading on the 'side-wall' and explicitly states that no 'externally applied force' is to be applied. None of the defined test loads therefore relate to the risk of detachment of externally-fitted structures, such as the transit panels, due to the influence of external in-service loads.

82 The CSC requires that a national government or authorised organisation determines whether re-testing is necessary in order to re-certify a container that has been structurally modified.

83 The recertification of containers CPIU 9006580 and 9006609, after their modification, was an opportunity for an independent structural assessment that could have considered the adequacy of the bolted joint used to attach the transit plates. However, with no relevant load case (or other structural requirement), there was no obligation for Broadcrown (or its supplier) to arrange this. The reliance on a regulatory structural assurance regime that excluded test loads relevant to the detachment of the transit plates was a probable underlying factor (paragraph 73).

ISO 1496-1 and UIC 592-2

84 Both ISO 1496-1 and UIC 592-2 define structural test requirements for freight containers (paragraphs 50 and 51). They are similar in nature to the test loads in the CSC and relate to similar structural integrity considerations (paragraph 80).

85 Like the CSC, neither standard includes a test load (or other structural requirement) that relates to externally applied loads on external attachments.

Railway industry standards

86 Structural requirements for railway freight vehicles are included in both Railway Group standard GM/RT 2100, 'Requirements for rail vehicle structures', and the 'Technical Specification for Interoperability relating to the subsystem Rolling Stock – Freight' published by the European Union. GM/RT 2100 includes specific requirements concerning the effect of aerodynamic and inertial loads on rail vehicle structures, however neither document refers to any relevant structural requirement concerning freight containers carried on the railway.

[16] The CSC allows use of ISO 1496 as an alternative to the test loads it defines. The supporting HSE document, 'Approval of containers' (paragraph 46), requires testing in accordance with the CSC test loads (or alternatively those in the ISO 1496); no additional test loads are specified.

Identification of structurally defective containers in the transport chain

87 **Visual examinations were the only means of determining whether a freight container was fit to travel by rail. This was a possible causal factor.**

88 The RAIB examined the actions, processes and practices of the following parties involved in transporting containers CPIU 9006580 and 9006609 to understand the means available to prevent a structurally defective container being carried by rail:

- the freight forwarder;
- the container carrier;
- the road haulage company;
- the inter-modal terminal operator; and
- the freight train operator.

89 Given the national and international use of the CSC in assuring structural safety, the RAIB sought to establish the nature of any related CSC approval checks that are carried out during transportation. It was recognised, however, that the CSC approval process is currently unable to identify the defects highlighted by this accident (paragraphs 79 to 83)[17].

Freight forwarder

90 The RAIB found no evidence that, other than passing on information requests from the carrier it contracts (paragraph 55), LV Shipping make any physical or documentary checks regarding the structural integrity of a container for which it is arranging transportation.

91 LV Shipping uses standard trading conditions[18]. Under these, customers warrant that their containers are 'fit for purpose'.

Container carrier

92 Maersk Line owns and operates its own fleet of freight containers, and has processes in place to regularly examine these under the rules of the CSC. It also carries customer-owned containers. It terms these '*shipper-owned containers*' (SOCs). It requires all SOCs to have a valid safety approval plate that displays evidence of examination in accordance with CSC rules.

93 Containers CPIU 9006580 and 9006609 were SOCs. Before their collection from Broadcrown's works, Maersk Line sought confirmation that both were compliant with CSC requirements by asking Broadcrown to sign 'Shipper Owned Container ('SOC') Request Forms' (paragraph 55). Maersk Line's normal process is to put the request form details into the computer system it uses to track and manage freight containers shipped by sea.

94 If there is an issue with the request form for a particular container, the computer system flags an error. The system, however, does not track land-based container movements. As a result, a flagged error would not prevent carriage by rail (or road). Maersk Line has no other operational system or process for this purpose.

[17] The RAIB has made recommendation 3 to address this.

[18] Published by the *British International Freight Association*.

Road haulage company

95 The drivers who collected the two containers from Broadcrown's works signed to say they were 'in good condition' (paragraph 26). It is unlikely that they would have been expected to use anything more than visual observation to determine this.

Inter-modal terminal operator

96 The Roadways staff that handle freight containers at BIFT are required to be vigilant regarding the reporting and rejection of containers with structural defects. However, identification is only by visual observation.

97 No checks are made of safety approval plates to confirm whether or not a freight container has a valid CSC approval. Roadways are not aware that any such checks are carried out at other UK inter-modal freight terminals.

Freight train operator

98 The RAIB found no evidence that Freightliner seek, or are required to seek, any certification regarding a freight container's structural integrity (for instance, by reference to CSC approval and examination status) before its is considered fit for rail carriage:

- Freightliner has 'standard conditions of carriage'. Under these, customers warrant that a freight container is suitable 'for transit'. The conditions, however, make no requirement for a customer to confirm any certification relating to structural integrity or CSC approval status.
- Railway Group standard GO/GN 3653, 'Working manual for rail staff, freight train operations', the so-called 'white pages', makes general reference to the need for a competent person to confirm that a 'load unit' (in this case a freight container) is 'identified … as suitable for acceptance' before 'being loaded on a rail vehicle' (clause G2.1). However, it includes no reference to checks regarding structural certification, or CSC approval status.
- Freightliner document PSD/0300 issue 4, 'Rail operations standards, intermodal' defined Freightliner's procedures relating to container train operation at the time of the accident. Amongst other aspects, it lists the detailed checks to be undertaken, during train preparation, before a container train can depart. Likewise, it includes no reference to checks regarding structural certification, or CSC approval status[19].

99 Train preparation at BIFT is by Roadways staff who are trained by Freightliner, and work in accordance with its procedures. In particular, PSD/0300 required the person(s) involved to check that:

- there are 'No bulges in the container sides or sheets'; and
- there is 'No loose equipment on…containers that could fall from the train en-route'.

[19] This document was revised after the accident. It now includes reference to the 'CSC plate' and its purpose. However, no checks are required regarding a freight container's CSC approval status.

100 Staff make all these checks visually. Without a detailed understanding of the bolted joints used to attach the transit plates, or an assessment of their structural integrity, it would have been unreasonable for even a highly experienced member of staff to have recognised that the bolted joints were defective. It is unsurprising therefore that the shift supervisor, who checked train 4L68 on 18 July 2011, found nothing untoward with the transit plates on containers CPIU 9006580 and 9006609, and allowed the train into service (paragraph 28).

Summary of conclusions

Immediate cause

101 The immediate cause of the accident was that screws, which were securing the transit plate on the right-hand side of container CPIU 9006609, came loose enabling the upper part of the transit plate to detach and infringe the path of the approaching tamper (**paragraph 60**).

Causal factors

102 The causal factors were:

a. The loosening of the screws securing the transit plate that was initiated by a loss of preload in the bolted joints as a result of the continued compression of the polyethylene foam after tightening (**paragraphs 63 and 105, Recommendation 1**).

b. That Broadcrown did not require that the bolted joints were designed or assessed against an external load criterion, or consider their possible failure mechanisms. Broadcrown's response to previous related incidents is a possible factor to this (**paragraphs 70 and 75, Recommendation 1**).

c. The lack of a specific external requirement for the bolted joints to be independently assessed (**paragraph 76, Recommendations 2 and 3**).

103 It is possible that the following factor was causal:

a. The reliance only on visual examinations when determining whether a freight container is fit to travel by rail (**paragraphs 87 and 106, Recommendation 4**).

Underlying factors

104 A probable underlying factor was the reliance on a regulatory structural assurance scheme (the CSC) that excluded any requirement to assess freight container attachments (such as the transit plates fitted to container CPIU 900609) against any foreseeable external load criterion (**paragraphs 73 and 83, Recommendations 2 and 3**).

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

105 Broadcrown conducted a design review shortly after the accident, and decided that it would only fit transit plates on the inside of freight container enclosures. It has since developed assembly instructions and revised its build and inspection processes accordingly (paragraph 102a).

106 Freightliner and Roadways both issued safety alerts as a result of the accident requiring their staff to be vigilant and reject freight containers with panels fitted to the exterior 'until further notice'. Freightliner has since revised its operational procedures (although there is ambiguity in the wording) with the intent of preventing the rail carriage of such freight containers unless special arrangements are in place to mitigate any associated risks (paragraph 103a).

Recommendations

107 The following recommendations are made:[20]

1 *The intention of this recommendation is to make other companies, which design, modify or repair freight containers, aware of the criticality of bolted joints so that full consideration is given to ensuring that their integrity is sufficient for foreseeable in-service loads.*

The Health and Safety Executive should issue a safety bulletin to make manufacturers and users of converted freight containers aware of the need for a competent assessment of the adequacy of bolted joints, which are used to secure exterior attachments, when designing, modifying or repairing containers. It should also ask the organisations authorised to approve containers to cascade this information to their clients (paragraphs 102a and 102b).

2 *The intention of this recommendation is to ensure that, in the short term, CSC approval gives assurance that a competent organisation has considered the detachment hazards highlighted by this accident and judged that the associated risks are acceptable.*

The Heath and Safety Executive should request that the International Maritime Organization issue a safety brief to all bodies authorised to approve freight containers in accordance with the International Convention for Safe Containers. This should advise them of the need to consider the integrity of all exterior attachments, and their fixings, against all foreseeable in-service loads when approving new, modified or repaired containers (paragraphs 38, 39, 41,102c and 104).

continued

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

Additionally, for the purposes of regulation 12(1) of the Railways (Accident Investigation and Reporting) Regulations 2005, these recommendations are addressed to the Health and Safety Executive and the Office of Rail Regulation to enable them to carry out their duties under regulation 12(2) to:

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

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

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

3 *The intention of this recommendation is to ensure that, in the longer term, CSC approval gives assurance that the risk of a structure detaching from a freight container is acceptably low during handling and for all modes of surface transportation.*

The Health and Safety Executive should request that the International Maritime Organization reviews international reports of structural detachment from freight containers and evaluates the risk to human life during transportation and handling. If appropriate, it should update the International Convention for Safe Containers to include requirements for the integrity of all exterior attachments, and their fixings, against all foreseeable in-service loads (paragraphs 38, 39, 41, 102c and 104).

4 *The intention of this recommendation is that rail freight operators have arrangements in place sufficient to manage the risk associated with the structural integrity of freight containers carried on the railway. These management arrangements should not be solely reliant on visual checks, because structural defects may be hidden. Management of the risk could be achieved through:*

- *demonstration of compliance to safety requirements (eg of the CSC), and, where necessary, additional actions to address risks not covered; or*
- *structural assessments by a suitable qualified and experienced person.*

Implementation of the above could be through setting specific contractual requirements or by checking that there is evidence when accepting the container onto the railway.

Note: once Recommendation 2 (International Maritime Organization to issue a safety brief) or Recommendation 3 (updating of the CSC) has been implemented, compliance with the CSC would be sufficient in its own right.

Freightliner should review its current operating procedures and conditions of acceptance for freight containers. It should confirm that the arrangements in place to ensure that containers (including any externally attached structures) have been assessed as having sufficient structural integrity are sufficient for the risk posed (paragraph 103a).

This recommendation may also be applicable to other train operators that carry freight containers.

Appendices

Appendix A - Glossary of abbreviations and acronyms

BIFT	Birmingham intermodal freight terminal
CCTV	Closed circuit television
CSC	International Convention for Safe Containers
HSE	Health and Safety Executive
IMO	International Maritime Organization
ISO	International Organization for Standardization
SOC	Shipper-owner container
UIC	International Union of Railways

Appendix B - Glossary of terms

British International Freight Association	Trade association for UK companies engaged in the international movement of freight.
Certificate of readiness	Document that shows a train has been prepared in accordance with required standards and is verified as safe for travel.
Cess	The area along the side of the railway track.
Classification society	An organisation that develops and applies technical standards to the design, construction and assessment of ships (and other marine facilities) and which carries out related surveys.
Cold form	A process to shape metal that does not involve heat or material removal.
Container carrier	A company that transports freight containers.
Down	In the direction away from London.
Freight forwarder	A company or individual that organises the shipment of goods on behalf of a customer.
Freight operating company	A company that operates freight trains on the railway.
Goods loop	A track that trains, usually carrying freight, can be diverted onto to allow another train to pass.
Headstock	The horizontal beam on a railway wagon that the buffers and couplings are attached to.
Health and Safety Executive	The Health and Safety Executive is an enforcing authority responsible for health and safety regulation in Great Britain.
Inter-modal	The movement of freight by more than one mode of transport (eg road, rail and sea).
Inter-modal freight terminal	A facility where freight containers are transferred from one mode of surface transport to another (eg from road to rail).
International Maritime Organization	The specialised agency of the United Nations with responsibility for the safety and security of shipping and the prevention of marine pollution by ships.
International Organization for Standardization	Worldwide federation of national standards bodies that develops and publishes international technical standards.
International Union of Railways	An association of international railway companies that, among other roles, develops railway specifications, standards and interfaces.

Milepost	A post at the side of the line which indicates the distance from a datum point, usually the start point of that line.
M8	Term used to describe a fastener that has a metric screw thread of 8 mm nominal diameter.
Power signal box	A large signal box which controls the points and signals over a large area by electrical means.
Pre-departure examination	A physical examination of a freight train that is undertaken before it is allowed to run on the railway.
Preload	Once the mating surfaces of a bolted joint contact, further tightening the bolt results in it extending. The resultant axial force in the bolt is known as the preload.
Safety approval plate	A permanent rectangular plate on a freight container that shows it has a valid CSC approval.
Shipper-owned container	A freight container that is owned by the party requiring the goods to be carried.
Switches and crossings	Track that allows trains to move from one line to another.
Tamper	A maintenance vehicle that aligns track and simultaneously compacts the supporting ballast.
Tank container	A special type of freight container designed for the carriage of gases, liquids and solid substances (dry bulk).
Threaded insert	A mechanical element that can inserted and secured in a drilled hole so that a threaded faster can be screwed in.
Train document	A document detailing various information about a freight train (eg train formation, length and maximum speed) that is given to the driver by the person responsible for its preparation.
Up	In the direction towards London.
West Coast Main Line	The railway route that runs from London Euston to Glasgow, including the lines to Birmingham, Liverpool and Manchester.

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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