



Rail Accident Investigation Branch

# Rail Accident Report



## Road-rail vehicle runaway incidents at Brentwood, Essex and at Birmingham Snow Hill 4 November & 31 October 2007

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.

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# Road-rail vehicle runaway incidents at Brentwood, Essex and at Birmingham Snow Hill 4 November & 31 October 2007

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## Introduction

- 1 The sole purpose of a Rail Accident Investigation Branch (RAIB) investigation is to prevent future accidents and incidents and improve railway safety.
- 2 The RAIB does not apportion blame, liability or carry out prosecutions.
- 3 Appendices at the rear of this report contain the following glossaries:
  - acronyms and abbreviations are explained in Appendix A; and
  - technical terms (shown in *italics* the first time they appear in the report) are explained in Appendix B.
- 4 All mileages in this report are measured from the following zero points:
  - London Liverpool Street for the incident at Brentwood; and
  - London Paddington, via Didcot, for the incident at Birmingham Snow Hill.
- 5 The RAIB was notified of the *road-rail vehicle* (RRV) runaway at Brentwood and attended the incident site. After publishing details of the incident on its website, the RAIB was informed of the earlier RRV runaway at Birmingham Snow Hill. The RAIB decided to conduct a joint investigation as the similarities between the two incidents – the vehicle types, operations taking place and parties involved – highlighted the likelihood of common safety learning.

## Summary of the report

### Key facts about the incidents

#### Incident at Brentwood

- 6 At around 10:12 hrs on 4 November 2007 an *operator* and *machine controller* were putting a Basket 14 RRV (Figure 3), a *mobile elevating work platform* (MEWP) type of RRV made by Basket srl, on the track near Brentwood station (18 miles 16 chains) when it ran away westward to Romford and London (Figure 1). The operator and machine controller were unable to stop the Basket 14 RRV before it gathered speed. After travelling some four miles, the machine left the *possession* arranged for its protection and the operator, who was in the work basket, jumped clear. The machine ran for a further three miles before Network Rail staff were able to stop it west of Romford station (12 miles 30 chains). The operator was injured and required hospital treatment.

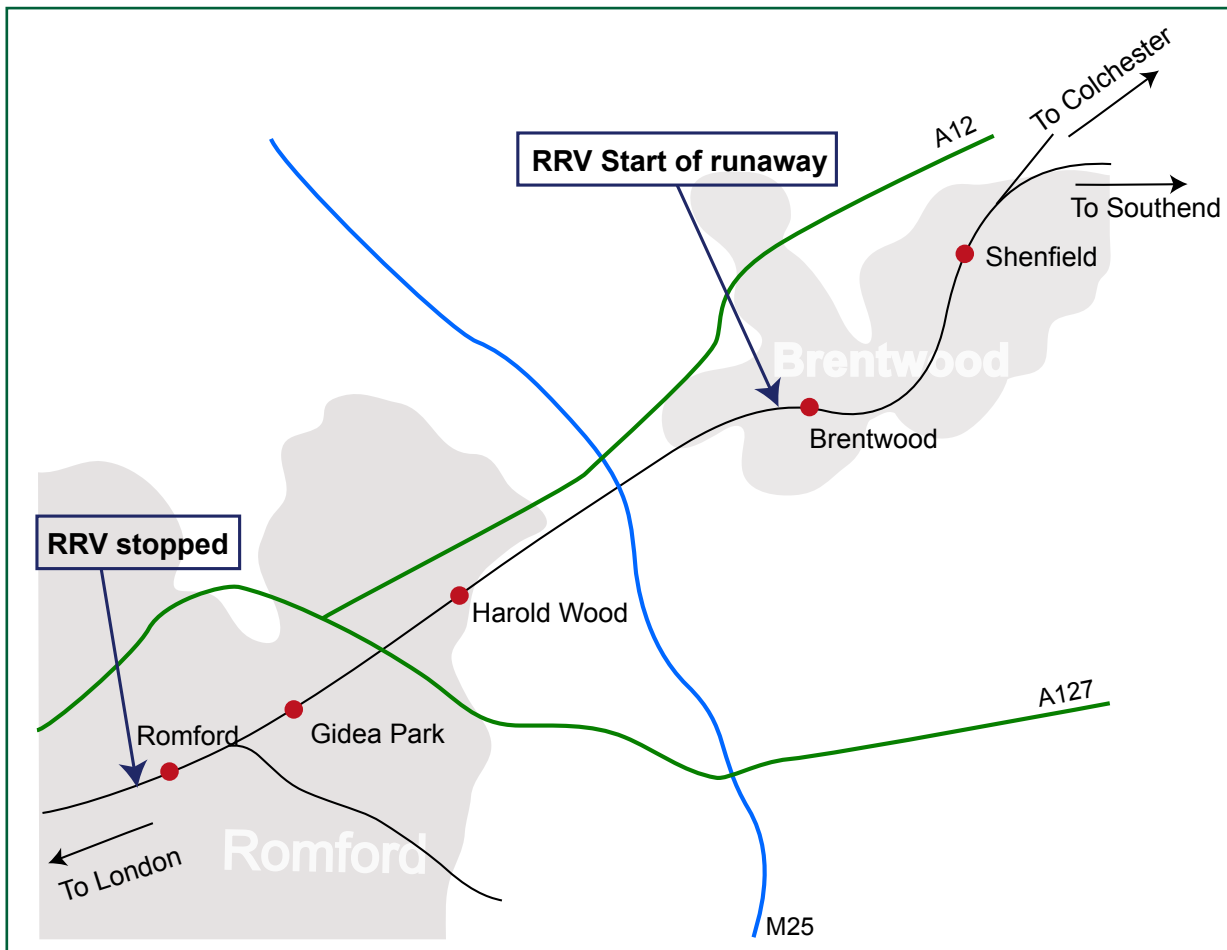


Figure 1: Map showing location of the incident at Brentwood

### Incident at Birmingham Snow Hill

- 7 At around 02:30 hrs on 31 October 2007, a TD-18 RRV (Figure 9), another MEWP type of RRV, was being removed from the track near Birmingham Snow Hill station (129 miles 36 chains) when it ran away (Figure 2). It then collided with a Basket 14 RRV parked 10-15 metres away. There were two persons in the work basket of the Basket 14 RRV and another was in the driving cab of the TD-18 RRV. They all managed to move clear before the collision, and no-one was injured.

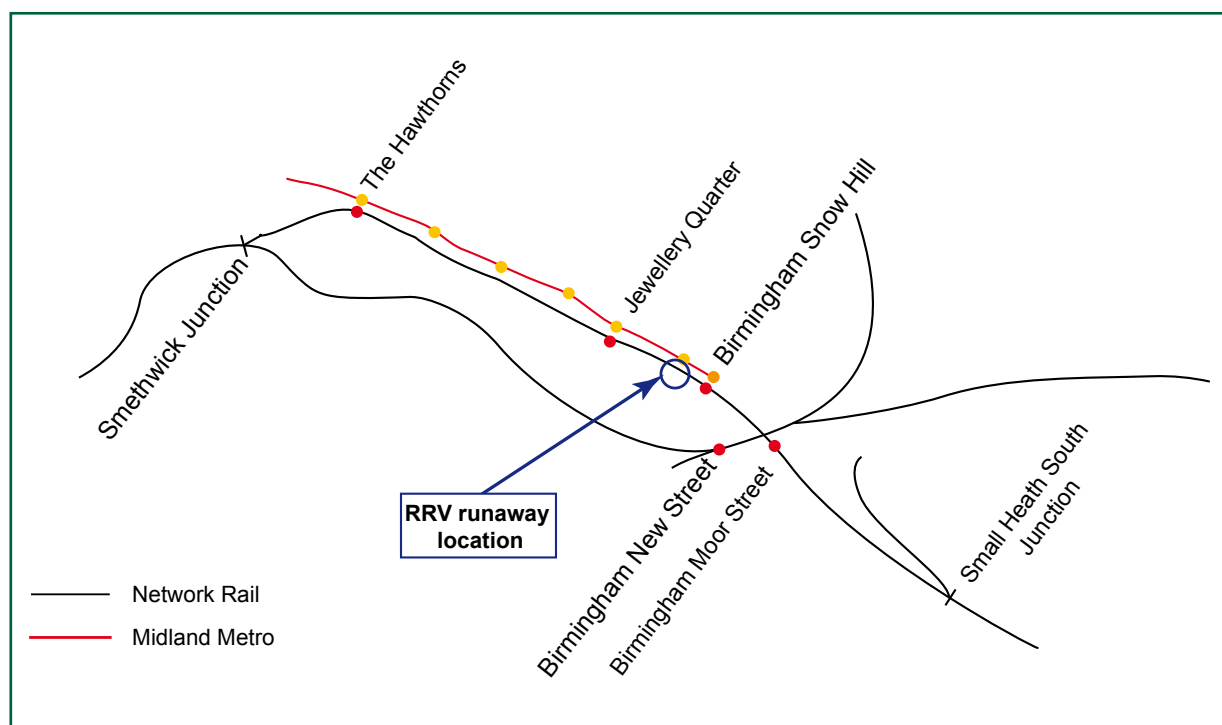


Figure 2: Map showing the location of the incident at Birmingham Snow Hill

### **Immediate cause, causal and contributory factors, underlying causes**

- 8 The immediate cause of both incidents was that the RRVs started to run away because of the actions carried out during their *on/off-tracking*. They resulted in each of the RRVs being put in a condition where their rail wheels carried the full weight of the machine, but were unbraked - by either a direct or an indirect means.
- 9 Causal factors for the incident at Brentwood were:
- During on-tracking, it was not observed that, because *locking pins* on the Basket 14 RRV were incorrectly located, there was no contact between the rail and road wheels at the one end of the machine before the *rail gear* was lowered at the other.
  - On site, and before starting to on-track, the operator did not reach an understanding with the machine controller regarding the specific actions they were each going to take. No procedure or training specifically required this.

- 10 The causal factor for the incident at Birmingham Snow Hill was:
- During off-tracking, there was no check for contact between the rear rail and road wheels before deciding to raise the front rail gear. No training was identified that specifically required this.
- 11 Contributory factors for the incident at Brentwood were:
- The general lack of awareness of the scope of the *Sentinel* competencies held by the machine controller, and that although they showed he was competent to *control* the Basket 14 they didn't show he could assist the operator with on-tracking it.
  - No previous appreciation that incorrectly located locking pins on a Basket 14 RRV can prevent braking being re-established - because the *rail gear arms* cannot fully lower - and therefore, that no mitigation measures were implemented to address this risk.
  - The machine controller's decision to press the *emergency stop button*, which prevented braking being re-established because hydraulic power was cut.
- 12 Contributory factors for the incident at Birmingham Snow Hill were:
- The decision that an interlock was not needed in the rail gear deployment system of a TD-18 RRV in response to an *Improvement Notice* issued by the *Office of Rail Regulation (ORR)*, the safety regulator for railways in the Great Britain.
  - During off-tracking it was not ensured that the *gear selector* was in 'neutral'.
  - The operator of the TD-18 RRV having insufficient time to decide the correct course of action for re-establishing braking.
- 13 An observation relevant to both incidents was the general lack of awareness of the severity of the gradient at the *road-rail access points* used. Another observation, relevant to the incident at Brentwood, was that if the Basket 14 RRV had been fitted with the system that was being developed at the time to comply with the ORR Improvement Notice (the *wander-lead modification*), it is unlikely to have runaway.

## Severity of consequences

### Incident at Brentwood

- 14 The operator was off work for six weeks because of his injuries.
- 15 With the work basket leading, the Basket 14 RRV ran uncontrolled for seven miles, at speeds that reached over 35 mph (56 km/h). Three miles were on an electrified line on which passenger trains were operating and stations were open to the public. There was the potential for more serious consequences. The operator in the work basket, staff working on the track, train crews and members of the public were all at risk if, for example, a collision or derailment had occurred.

### Incident at Birmingham Snow Hill

- 16 No-one was injured.
- 17 The amount of damage to the work basket of the Basket 14 RRV, and the loss of survival space, shows that those on and near the machine were at risk of serious injury had not they not managed to evacuate quickly.



## Recommendations

- 18 Recommendations can be found in paragraph 248. They relate to the following areas:
- the need for operators to come to an understanding with those assisting with on/off-tracking, and when this assistance is required;
  - validating on/off-tracking procedures and their implementation;
  - the training of machine controllers and the limitations which apply to Sentinel competencies issued to them;
  - emergency actions required in runaways;
  - validating the decisions made in response to the Improvement Notice issued by ORR; and
  - publication of gradient information.

## The incident at Brentwood

### Summary of the incident

- 19 At around 10:12 hrs on 4 November 2007 an operator and machine controller were on-tracking a Basket 14 RRV at a road-rail access point just west of Brentwood station (18 miles 16 chains). RRVs are vehicles that can operate both on railway track (rail mode) and the road (road mode). On-tracking an RRV is the operation of changing from road mode to rail mode. Off-tracking is operation of changing back to road mode. This operation is normally carried out at a place on the railway that is designated for this purpose: a road-rail access point.
- 20 The operator and machine controller were working for Elec-Track Installations (ETI), a contractor of Network Rail, and were preparing to start planned renewal work on *overhead line equipment* (OLE).
- 21 The road-rail access point was close to a summit on the railway, Ingrave Summit (19 miles 20 chains), Figure 4, and as the machine was being on-tracked it began to run away westward, towards Romford and London. The operator, who was in the machine's work basket, and the machine controller, who was trackside and had started to run alongside, were unable to stop the machine before it gathered speed.
- 22 The machine ran for a total of seven miles - three miles of which were outside the possession arranged for the renewal work - until staff, from the Romford OLE maintenance depot, stopped it west of Romford station (12 miles 30 chains), Figure 3. There was no material damage.
- 23 The machine had started to slow down as it passed Harold Wood station (14 miles 76 chains), and the operator jumped clear as it left the possession on its approach to Gidea Park station (13 miles 41 chains). He sustained injuries requiring hospital treatment, but he was not detained overnight.



Figure 3: The Basket 14 RRV stopped west of Romford station after the runaway

## The parties involved

- 24 Network Rail own and operate the railway infrastructure of the line on which the incident took place. The location is on the Anglia Route of its South East Territory.
- 25 ETI was responsible for the overhead line equipment renewal work planned for 4 November 2007.
- 26 ETI hired the Basket 14 RRV that ran away from Rail Access Platforms Ltd, who owned and maintained it, and delivered it to site.
- 27 Interfleet Technology (Interfleet) was the appointed *vehicle acceptance body* (VAB) for the Basket 14 RRV used. They assessed the compliance of the Basket 14 RRV with the relevant railway standards and issued approval certificates.
- 28 Network Rail, ETI<sup>1</sup>, Morgan Est<sup>1</sup>, Rail Access Platforms Ltd and Interfleet freely co-operated with the investigation.
- 29 The machine controller was on ETI's list of approved agency staff and worked for it when requested. The operator and the other key people involved on site were permanent ETI employees.
- 30 The operator joined ETI in around 1994 and had 23 years railway experience, mainly relating to overhead line equipment work. He had operated MEWPs, including Basket 14 RRVs, on an almost weekly basis for between three and four years. ETI trained him and periodically assessed his competence. He held an ETI Certificate of Competence that was issued on 17 February 2007.
- 31 The machine controller had nine years of trackside work experience in a variety of roles. He held valid machine and crane controller Sentinel competencies for a range of RRV types, including 'MEWP' and '360 Excavator'. He had worked with Basket 14 RRVs before; the last previous occasion was the weekend before the incident. Entries in his Sentinel *machine and crane controller logbook* (Sentinel logbook) supported this.

## Location

- 32 The incident occurred on the four-track railway that runs east from London Liverpool Street station to Shenfield station (20 miles 16 chains).
- 33 All four tracks - the *up* Main and *down* Main lines and the up Electric and down Electric lines - are electrified. The signalling is *four aspect colour light*, controlled from the Liverpool Street *integrated electronic control centre* (IECC).
- 34 The road-rail access point used for on-tracking the Basket 14 RRV at Brentwood was on the down Electric line. When the machine ran away, it continued on this line until it was stopped, east of Romford station, opposite the OLE maintenance depot (11 miles 17 chains), Figure 4.

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<sup>1</sup> ETI went into administration in January 2008 having previously sold its isolation business and plant assets to Morgan Est, part of construction and regeneration group Morgan Sindall plc. Morgan Est now owns assets and employs a number of staff relevant to these incidents. Reference to ETI in this report is also intended to mean the organisation now responsible for the assets and staff relevant to this investigation.

35 There is a near constant downhill gradient of around 1 in 100 from the road-rail access point for around two miles (3.22 km) towards London. Then, on the approach to Harold Wood station, the gradient reduces. From there to the OLE maintenance depot it varies between 1 in 275 and level.

36 Figure 4 shows a plan of the site and the gradient profile of the line.

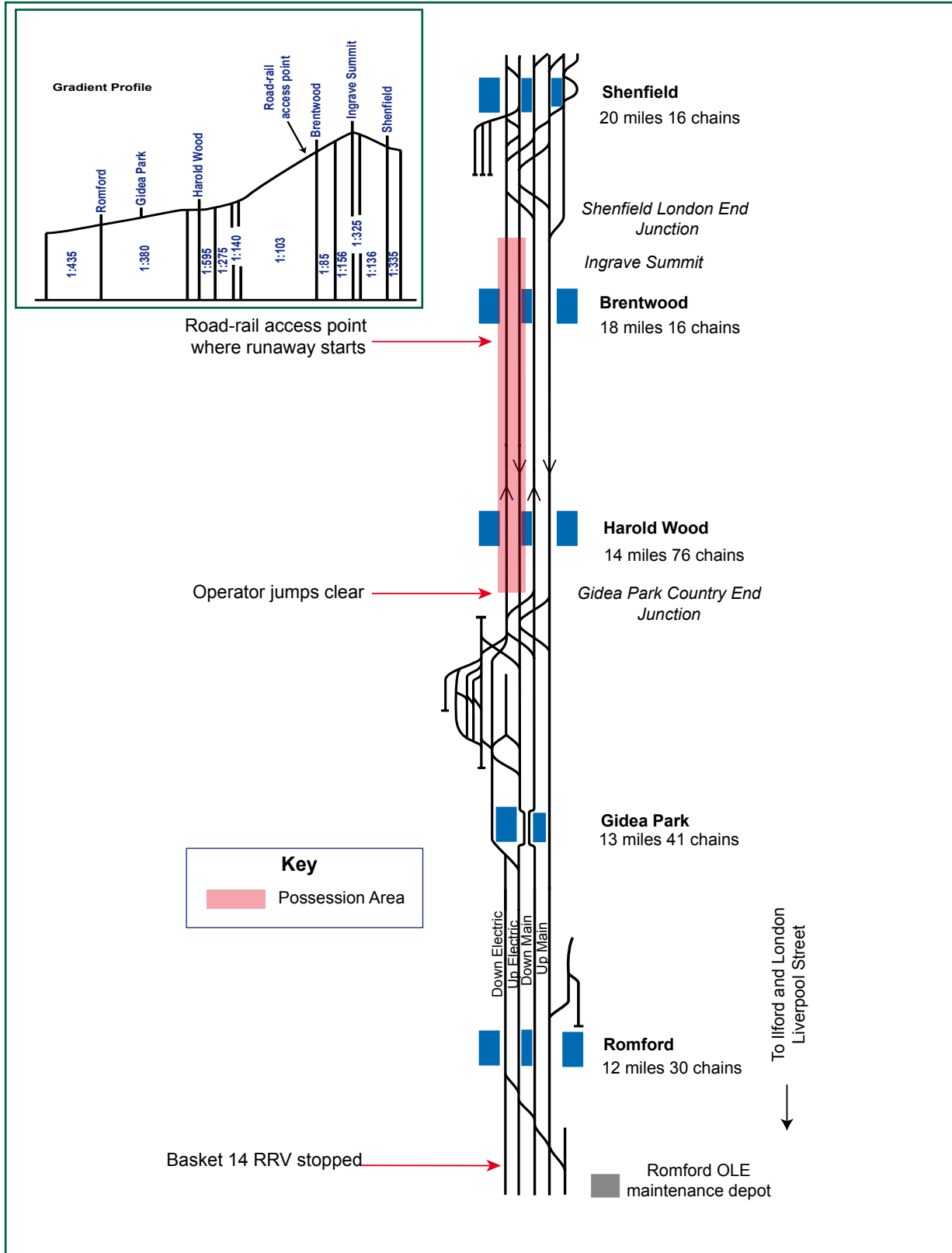


Figure 4: Site plan – incident at Brentwood

## External circumstances

- 37 The weather in the area on 4 November 2007 was dry and partly cloudy. It played no part in the incident.

## The road-rail vehicle

- 38 Basket srl, a manufacturer of access platforms based in Italy, specifically designed and built the Basket 14 RRV for use in the UK. Rail Access Platforms Ltd helped develop and agree the requirements.
- 39 At the time of this report, twenty Basket 14 RRVs operated in the UK; Rail Access Platforms Ltd owned thirteen and ETI the other seven.
- 40 The machine involved in the incident was built in 2003. Interfleet assessed its compliance with the *Railway Group standard* applicable at the time, GM/RT1300 issue 3 'Engineering acceptance of road-rail plant', and issued the *certificate of engineering acceptance* and the *certificate of conformance for vehicle maintenance*.
- 41 The Basket 14 RRV is a *high ride* RRV. RRVs of this type have rail idler wheels that are driven and braked by friction forces transmitted from road wheel tyres<sup>2</sup>. It has an elevating work basket - raised and lowered by a combined telescopic boom and scissor lift mechanism - which is fitted to a rotating superstructure mounted on its chassis. The machine has two driven road axles, one is steered and the other is fixed, and two control panels: one on the superstructure (the *ground control panel*) and one in the work basket (the *basket control panel*), Figure 10.

## Events preceding the incident

- 42 ETI was contracted to carry out renewal work in the Brentwood area on 4 November 2007. A possession was arranged of the up and down Electric lines between Gidea Park Country End Junction and Shenfield London End Junction (see Figure 4). The adjacent up and down Main lines were open to traffic.
- 43 ETI planned to use three RRVs for the renewal work. It had been using its own Basket 14 RRVs on earlier work, but these had been taken out of use so they could be modified to comply with the ORR Improvement Notice (paragraphs 162 to 172). It had hired machines from Rail Access Platforms Ltd as replacements.
- 44 Rail Access Platforms Ltd delivered the Basket 14 RRV involved in the incident to site at Brentwood before the team doing the renewal work were due to meet up to start work on 4 November. An ETI fitter checked the machine and found no problems or defects.

<sup>2</sup> The incidents at Brentwood and at Birmingham Snow Hill both involved high ride RRVs. The friction forces used to brake the rail wheels on high ride RRVs are provided by pressing the rubber tyres - on the road wheels - into contact with either the *tread* of the steel rail wheel or a special steel spindle connected to the rail wheel. (The spindle usually has a ridge pattern on its contact surface – see, for example, the rail wheels in Figure 6.) For clarity in this report, contact of a road wheel with a rail wheel means contact of the rubber tyre with either tread or spindle.

- 45 The operator and machine controller travelled to Brentwood independently; they both arrived at around 09:00 hrs, the shift start time. They signed in with the ETI site supervisor and received briefs on the planned work and safety issues. The briefs included a reminder, issued by Network Rail, regarding compliance with specification NR/L2/RVE/0007, 'Specification for on and off-tracking of Road-Rail vehicles'.
- 46 The operator then went to the Basket 14 RRV and completed a standard list of pre-work checks using a form issued by ETI. He passed the completed form to the machine controller. Everything was found to be in order.
- 47 The machine controller, who was also acting as *controller of site safety (COSS)*, briefed the operator about the safety arrangements and completed a standard list of pre-work tasks detailed on another form issued by ETI. The tasks on the form, based on a checklist developed by the *M&EE Networking Group*, included checking the machine controller's and operator's certificates. Everything was found to be in order.
- 48 The site team placed metal ramps on the track to aid on/off-tracking at the road-rail access point and to prevent damage to the track and machine.
- 49 The *engineering supervisor* arrived at around 10:00 hrs. He briefed the site team after they had signed in with him and gave permission to on-track the Basket 14 RRV, which, at the time, was parked approximately 15 metres from the down Electric line on hardstanding.

### Events during the incident

- 50 The operator got into the work basket and drove the Basket 14 RRV to the road-rail access point, approaching the track at around 45 degrees. The machine controller helped guide him. The work basket was over the end of the machine with the fixed axle (the *fixed-end*); it was facing downhill toward Romford. The opposite end of the machine (the *steered-end*) was uphill. Figure 5 shows the orientation of the Basket 14 RRV, and the position of the operator. The machine controller was on the track nearby, most probably at the steered-end. On-tracking commenced at around 10:12 hrs.

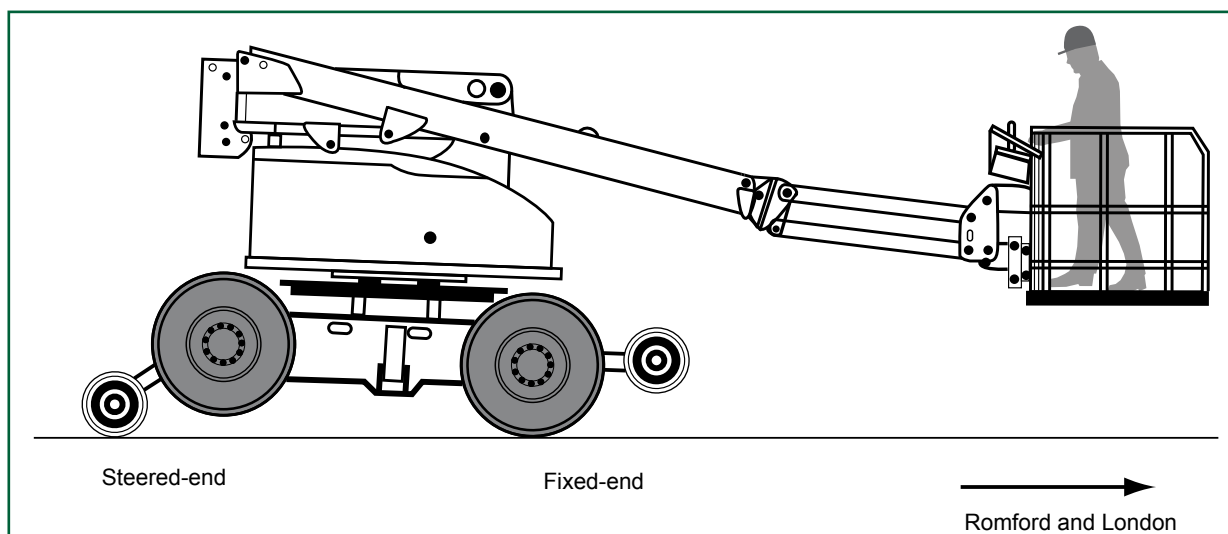


Figure 5: Orientation of Basket 14 RRV during on-tracking

- 51 The machine controller indicated that the rail wheels were in position, and the operator operated the *rail gear switch* on the basket control panel that lowered the rail gear. The position of the *changeover lever* - located on the superstructure - meant that the wheels at the steered-end lowered.
- 52 The rail gear stopped lowering before it had fully deployed, although the operator was unaware of this. The operator had heard the noise of the rail gear 'being engaged'. He also recalled that the machine controller had signalled to him that the rail wheels (on the steered-end) were in place. He could not check this himself, as his view from the work basket was obscured.
- 53 The machine controller's recollection did not include giving this signal. Evidence suggests he assumed the operator was solely responsible for lowering the rail wheels; he was not therefore specifically looking to see if the rail wheels had gone all the way down and therefore into contact with the road wheels. However, he did recall that they went into contact with the rail. He thought that the operator was placing the flanges of the rail wheels at the steered-end between the rails to help him align the rail wheels at the fixed-end later. He did not think this was unusual – he had seen operators do it before.
- 54 The machine controller moved the changeover lever to permit the operator to lower the rail wheels on the fixed-end (there is conflicting evidence as to whether the operator asked him to do this or if he did it of his own accord). He told the operator to lower the rail gear at the fixed-end; the operator then operated the rail gear switch to do this.
- 55 As the rail wheels on the fixed-end contacted the rail, the fixed-end road wheels were lifted clear and the Basket 14 RRV started moving towards Romford.
- 56 Realising this, the machine controller told the operator to put the rail wheels all the way down and get them into contact with the braked road wheels. The operator was already trying to do this, but they would not deploy further and make contact.
- 57 The Basket 14 RRV began to gather speed and the machine controller started to walk and then run alongside asking the operator what he should do. Neither of them knew what further action to take.
- 58 Thinking that a member of the site team had called 'press the emergency stop', the machine controller immediately reached forward and pressed the red button on the ground control panel marked 'STOP' (the emergency stop button). The action latched the emergency stop button in place, cut the engine and, as a result, the hydraulic power. This action prevented the operator being able to re-raise the rail gear, which if he had done would have brought the braked road wheels back into contact with the ground. Immediately realising the mistake, the machine controller attempted to unlatch the button; he was confident his action was successful.
- 59 The Basket 14 RRV was now travelling at significant speed and the machine controller tried to follow after it. Unable to keep up with the Basket 14 RRV, the machine controller called the ETI site supervisor. The supervisor told him that the signaller was already aware. The signaller at Liverpool Street had been told of the runaway by the person in charge of the possession (PICOP); the signaller stopped all train movements and confirmed with the *electrical control room* at Romford that power was isolated.

- 60 The operator, unable to take further action, stayed in the work basket and tried to make himself as safe as possible. As it descended the gradient towards Harold Wood station, calculations indicate that the Basket 14 RRV reached a speed exceeding 35 mph (56 km/h). The operator spoke to the ETI site supervisor on his mobile telephone and told him that it was too dangerous to get out.
- 61 As the gradient reduced before Harold Wood station, the Basket 14 RRV began to slow down. The operator managed to jump clear just after passing the possession limit signs on the approach to Gidea Park station. He sustained some minor injuries, but was able to walk to the station where he was met.
- 62 Having passed Gidea Park Country End Junction, the Basket 14 RRV was running outside the possession arranged for its protection and Network Rail planned to divert it into sidings at Ilford depot (8 miles 30 chains). However, staff from the Romford OLE depot, who had been alerted, managed stop it earlier using timbers placed on the track west of Romford station.

### Consequences of the incident

- 63 The operator was off work for six weeks because of the injuries that he sustained.
- 64 No-one else suffered physical injury and there was no significant material damage.
- 65 With the work basket leading, the Basket 14 RRV ran uncontrolled for seven miles at speeds which reached over 35 mph (56 km/h). Three miles were on an electrified line on which passenger trains were operating and stations were open to the public. There was the potential for more serious consequences. The operator in the work basket, staff working on the track, train crews and members of the public were all at risk if, for example, a collision or derailment had occurred.
- 66 Because of the nature of the incident, ETI offered the operator and machine controller counselling. Both of them accepted this and used the service.

### Events following the incident

- 67 The operator was taken to hospital where he was treated and discharged later the same day. Subsequently, he returned to site and was tested for drugs and alcohol. The results were negative.
- 68 While still on the track, the machine controller managed to call the operator who told him that he was not seriously hurt. Around this time, the machine controller recalled getting confused. He had established that the operator was not badly hurt and that the railway persons responsible were making the relevant emergency arrangements. He left the track and found himself by the A12 road and, for some reason, and in a daze, carried on walking into London. He stayed the night at a friend's house and got in contact with ETI the next day. He was tested for drugs and alcohol on the Tuesday, two days after the incident. The results were negative, however they were recorded as a 'fail' as he was not available for testing immediately after the incident.
- 69 ETI notified the RAIB of the incident at 11:12 hrs. Inspectors were deployed to site, the first arriving at 12:45 hrs.



- 70 The RAIB, with ETI's assistance, examined the Basket 14 RRV and found that:
- all rail wheels were on the track;
  - the rail gear arms, at both the fixed and the steered-ends, were in hard contact with locking pins; this was preventing the rail wheels contacting the road wheels, Figure 6;
  - the emergency stop button on the ground control panel was depressed and had been operated; and
  - the brakes and rail gear operated satisfactorily.

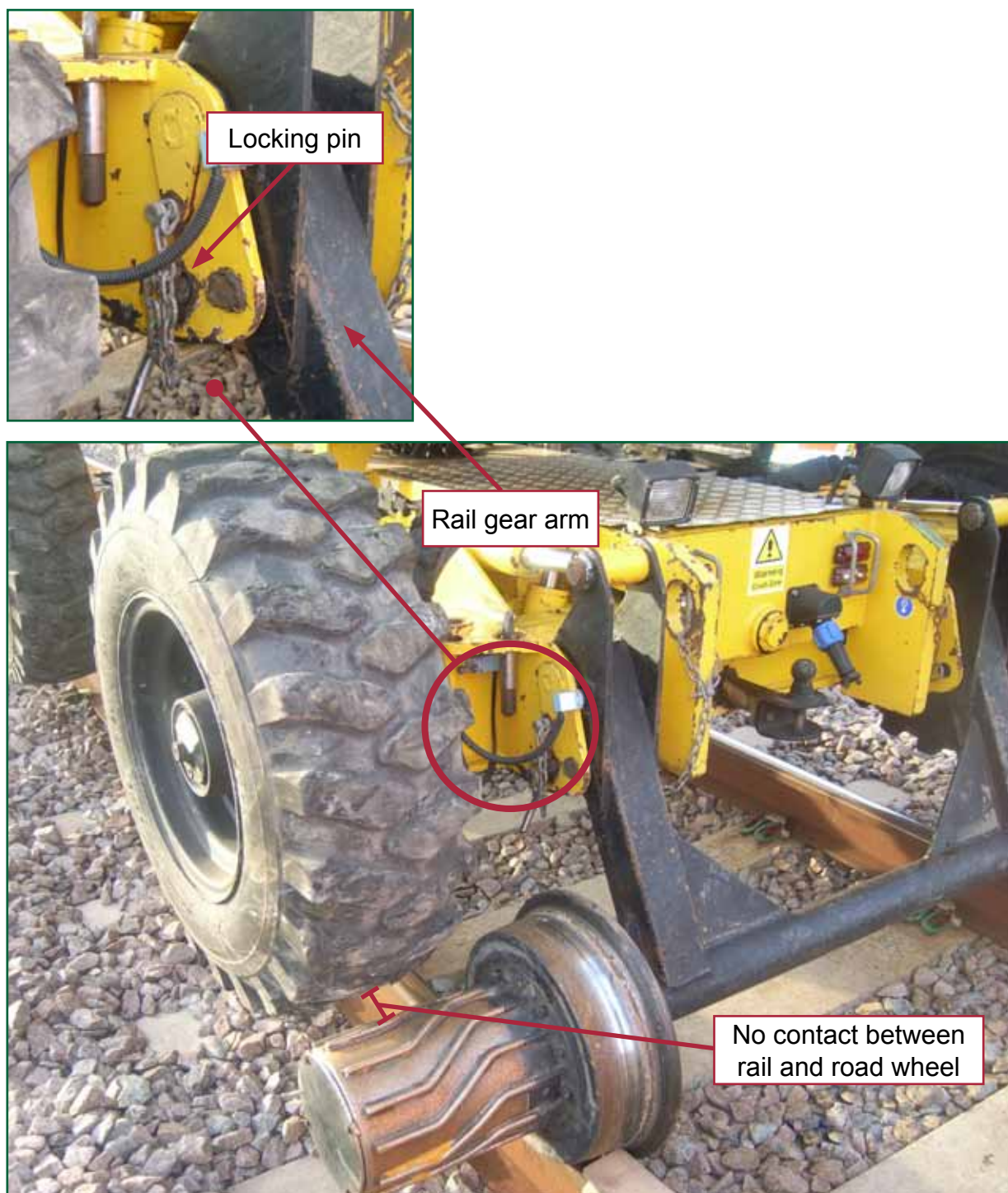


Figure 6: Basket 14 RRV locking pins and rail gear as found at Romford after the incident

## The incident at Birmingham Snow Hill

### Summary of the incident

- 71 At around 02:30 hrs on 31 October 2007, a TD-18 RRV was being off-tracked at a road-rail access point near Birmingham Snow Hill station (129 miles 36 chains). Mouchel Parkman Rail, a contractor working for Network Rail, had been using the machine for the routine examination of tunnels and other railway structures in the area.
- 72 As the machine was being off-tracked, it ran away towards the work basket of another RRV, a Basket 14 RRV, parked 10-15 metres away. There were two persons in the work basket of the Basket 14 RRV when the runaway started, and another was in the driving cab of the TD-18 RRV. They all managed to get clear before the cab collided with the work basket.
- 73 The work basket suffered damage, Figure 7. There were no injuries.



Figure 7: Damage as result of the TD-18 RRV colliding with the Basket 14 RRV (Photograph courtesy of Mouchel Rail Ltd)

### The parties involved

- 74 Network Rail own and operate the railway infrastructure near Birmingham Snow Hill. It is part of their London North Western Territory.
- 75 Mouchel Parkman Rail was responsible for the examination work, which was being undertaken as part of a ten-year contract with Network Rail for the examination of structures in the London North Western Territory. It contracted ETI to provide the two RRVs needed for the work.

- 76 ETI owned and maintained both RRVs, and employed the operators and machine controllers. All the other staff on site worked for Mouchel Parkman Rail.
- 77 Network Rail, Mouchel Parkman Rail, ETI and Morgan Est freely co-operated with the investigation.
- 78 The TD-18 RRV operator had over six years railway experience and had used the machine on over 350 previous shifts. ETI had trained him and, on 10 November 2005, issued him with an ETI Certificate of Competence.
- 79 The TD-18 RRV machine controller had worked for ETI for seven years as both operator and machine controller. He held Sentinel machine controller competence for a number of RRV types, including 'MEWP', 'lorry' and 'dumper'. On 31 May 2006 he was re-assessed and passed as competent on all of these.
- 80 There is no evidence that the actions of the operator and machine controller of the parked Basket 14 RRV contributed to the incident.

## Location

- 81 The incident occurred at the Livery Street road-rail access point, to the north west of Birmingham Snow Hill station in the centre of Birmingham. This section of the line is double track, the up line running towards Small Heath South Junction (126 miles 59 chains) in the south east of the city; the down line, towards Smethwick Junction (133 mile 32 chains) in the north-west, Figure 2. The line is not electrified.
- 82 The station is located between tunnels: Hockley No.1 and No.2 tunnels to the north-west, and Snow Hill tunnel to the south-east.
- 83 The Midland Metro light rail system terminates at a dedicated platform in Snow Hill station. From this, a separate double track line, electrified with a 750v DC overhead system, runs north west, through Hockley No.1 and No.2 tunnels, adjacent to the Network Rail up line.
- 84 The Livery Street road-rail access point is at 129 miles 55 chains. Here there is a downhill gradient of 1 in 53 toward Hockley No.1 and No.2 tunnels. The track, however, dips at 129 miles 57 chains and then rises at 1 in 93.
- 85 Figure 8 shows a plan of the site and the gradient profile of the line.

## External circumstances

- 86 The weather on the night of 30-31 October 2007 was fine and dry. It played no part in the incident.

## The road-rail vehicle

- 87 The TD-18 RRV, the machine that ran away, was a converted articulated road dumper truck. It is a high ride RRV and has a *knuckle-boom* elevating work basket, Figure 9. Except when the work basket is being used, the TD-18 RRV is operated from a chassis-mounted driving cab.

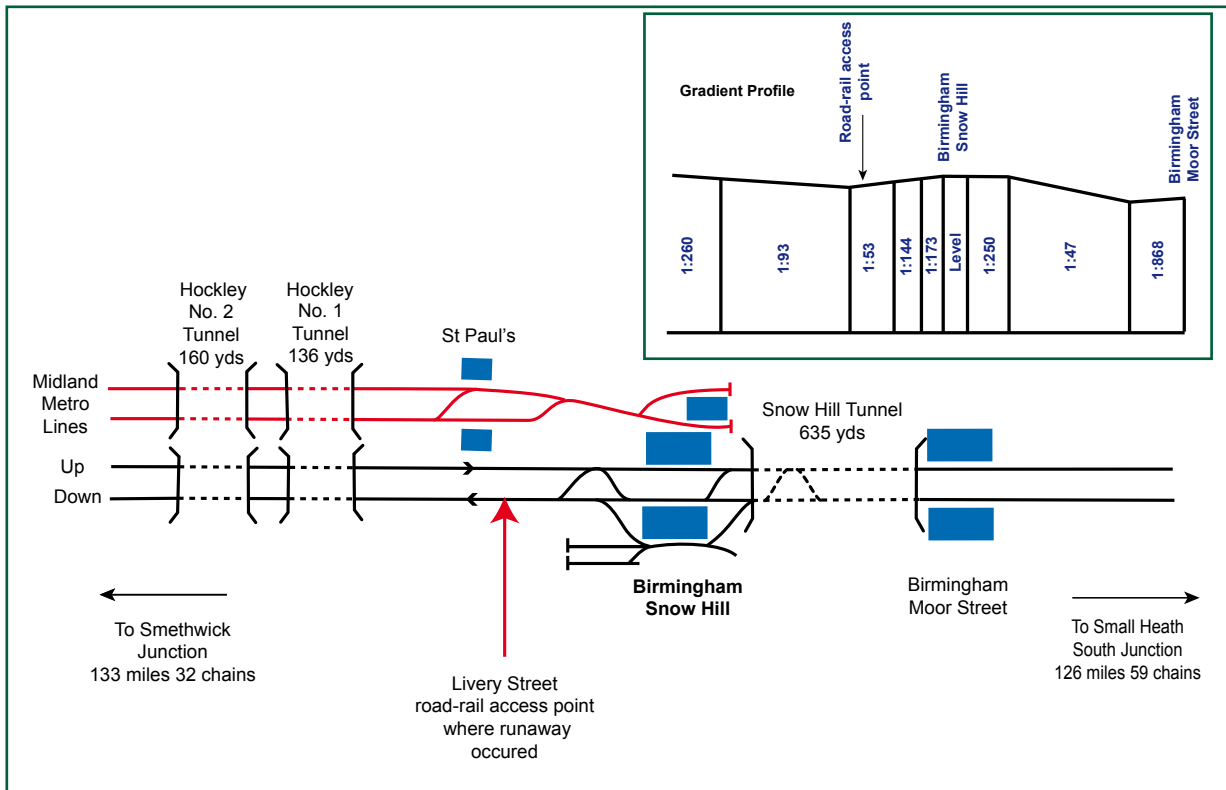


Figure 8: Site plan of incident at Birmingham Snow Hill



Figure 9: TD-18 RRV

- 88 ETI also owned two other TD-18 RRVs, the only others to operate in the UK: one has a crane attachment, while the other has both a crane attachment and an elevating work basket.

### Events preceding the incident

- 89 Mouchel Parkman Rail planned work for the nights between 29 October and 2 November 2007 to examine tunnels, *overbridges* and *retaining walls* near Birmingham Snow Hill station (between 128 miles 20 chains and 133 miles 25 chains).
- 90 The examination work was to be carried out with the aid of ladders and the two RRVs. The site team comprised four Mouchel Parkman Rail staff:
- a tunnel engineer (the senior person on site);
  - two bridge examiners (one also acted as engineering supervisor); and
  - an assistant examiner (who also acted as COSS);
- and four ETI staff: a machine controller and an operator for each of the two RRVs.
- 91 Mouchel Parkman Rail arranged a possession for the night of 30-31 October 2007 to give protection between Birmingham Moor Street station and Smethwick Junction, from 00:40 hrs until 05:15 hrs. They required the team to meet at the Livery Street road-rail access point each night at 00:40 hrs for the pre-work safety brief.
- 92 The TD-18 RRV and Basket 14 RRV machines were on-tracked on the down line at the Livery Street road-rail access point without incident. Continuing to work from the down line, the line furthest from the Midland Metro, the team proceeded to undertake the specific work planned for that night: the detailed examination of the Hockley No.1 and No.2 tunnels and local structures.
- 93 There were no issues arising with the examination work and the team completed it early. The TD-18 RRV and the Basket 14 RRV travelled back along the down line, roughly 10 metres apart, to the road-rail access point; the TD-18 RRV was leading, its cab facing the down direction.

### Events during the incident

- 94 The operator stopped the TD-18 RRV close to the Livery Street road-rail access point. The tunnel engineer, one of the bridge examiners and the assistant examiner were onboard. The assistant examiner got off, and he was trackside as the tunnel engineer then started to climb down the access steps.
- 95 The Basket 14 RRV parked downhill of the TD-18 RRV, some 10-15 metres away. The Basket 14 RRV operator and machine controller remained in the work basket and began passing down equipment to Mouchel Parkman Rail staff. The time was approximately 02:30 hrs.

- 96 The TD-18 RRV machine controller instructed the operator to raise the front rail gear. On doing this, the TD-18 RRV started to move forward slowly towards the parked Basket 14 RRV. The operator tried applying the footbrake and reversing, but neither was effective. Unable to arrest the movement and realising his cab was going to collide with the work basket of the Basket 14 RRV, the operator jumped out of the TD-18 RRV.
- 97 On the Basket 14 RRV, the operator and machine controller managed to get out of the work basket and, together with one of the bridge examiners who was nearby, move clear of the approaching TD-18 RRV.
- 98 The TD-18 RRV collided with the Basket 14 RRV and stopped. Once stationary, the TD-18 RRV machine controller observed a gap of approximately 40 mm between the rear rail and road wheels.

### Consequences of the incident

- 99 No-one was injured and material damage was limited to the parked Basket 14 RRV.
- 100 The loss of survival space as result of the damage to the work basket of the Basket 14 RRV (Figure 7) shows that, if they had not managed to evacuate quickly, those on and near the machine were at risk of serious injury.

### Events following the incident

- 101 After the incident, everyone got clear of the two machines and the TD-18 RRV operator was instructed to get the TD-18 RRV off the track, which he did. An attempt was also made to off-track the Basket 14 RRV, but the basket control panel was too badly damaged.
- 102 At around 02:45 hrs, the ETI on-call operations manager was notified, and the ETI plant manager and plant foreman were sent to site. The PICOP and Network Rail control were also notified. Arrangements were made for routine drug and alcohol testing of the operator and machine controller of the TD-18 RRV. Both results were negative.
- 103 The plant manager and plant foreman arrived around 04:00 hrs and examined the TD-18 RRV. They found it off-tracked (in road mode) with the engine running. The RRV was in working order, with no significant damage; they found no faults or mechanical problems. They also checked that, with the gear selector in 'neutral', the rear rail wheels were braked.
- 104 The Basket 14 RRV controls were repaired, the site was cleared and, at 04:20 hrs, handed back to the PICOP.
- 105 The RAIB did not attend the incident as ETI did not report it, contrary to the requirements of the Railways (Accident Investigation and Reporting) Regulations 2005. The incident was subsequently notified to the RAIB by the National Union of Railway, Maritime and Transport Workers after the incident at Brentwood had occurred.

## The Investigation

### Investigation process

- 106 The investigation sought to understand the events and causal factors associated with the two incidents, with particular reference to:
- the actions taken to improve the safety of RRVs as a result of previous runaway incidents – in particular at Copenhagen Tunnel, near London King’s Cross, on 15 October 2006; and
  - the training and competence management of operators and machine controllers.
- 107 The investigation’s primary focus was the incident at Brentwood. The RAIB was notified immediately of this and attended the incident site. The consequences to the operational railway were more severe than at Birmingham Snow Hill and there were also physical similarities with earlier runaway incidents. The RAIB has primarily investigated the incident at Birmingham Snow Hill to identify common issues that reinforce safety learning from Brentwood.
- 108 Information was obtained from the following sources:
- statements from staff who were on site - both at the time of the incidents, and immediately after - including those collected for the ETI and Mouchel Parkman Rail’s formal investigation of the incident at Birmingham Snow Hill;
  - photographs taken at Romford by the RAIB;
  - photographs taken by Network Rail and their contractors;
  - documents provided by Network Rail, ETI, Rail Access Platforms Ltd, Mouchel Parkman Rail and Interfleet;
  - information supplied by Network Rail, ETI, Rail Access Platforms Ltd and Interfleet;
  - standards issued by the *Railway Safety and Standards Board* (RSSB);
  - training and competence records; and
  - results of examinations of the RRV types involved.

## Key Information

### The Basket 14 RRV that ran away at Brentwood

- 109 Figure 10 shows the principal features of the Basket 14 RRV. It shows the machine with the rail wheels in both road mode (dashed lines) and rail mode (solid lines) positions. In road mode, the road wheels are on the ground and the rail wheels are up. When going to rail mode, the rail wheels lower onto the rail and then rotate around until they press into contact with the road wheels – the latter operation raises the machine and lifts the road wheels off the ground.
- 110 One set of rail gear is fitted at each end of the machine. Each consists of rail wheels that are connected to arms, which in turn pivot on the chassis (the rail gear arms), Figure 11. Hydraulic rams lower and raise the rail gear by rotating these arms. When the rail wheels are fully down and in contact with the road wheels, a hole in each rail gear arm lines up with one in a bracket on the chassis (the chassis bracket). Locking pins can then be inserted to secure the rail gear in place. There are four locking pins, two for each set of rail gear.
- 111 For most of the time the basket control panel is used to operate the Basket 14 RRV. The ground control panel is only used for starting the machine and controlling it in emergencies. There is a key switch on the ground control panel that is used to select which control panel is operative. There are no driving or steering controls on the ground control panel.
- 112 The rail gear is lowered (and raised) using a toggle switch (the rail gear switch); there is one on each control panel. The switch only operates one set of rail gear at a time. When the rail gear switch is operated, the position of a changeover lever (Figure 10) determines whether the front or rear rail gear is lowered or raised. This lever, mounted separately on the superstructure, moves a valve that diverts oil to the hydraulic rams at the end selected.
- 113 Emergency stop buttons are located on both control panels. They are a requirement of the European standard EN280 'Mobile elevating work platforms – design calculations – stability criteria – construction-safety – examinations and tests'.
- 114 On the Basket 14 RRV, none of the rail wheels are fitted with brakes. As is usual on high ride RRVs, in rail mode the braking is indirect and reliant on frictional contact with the braked road wheels.

### The TD-18 RRV that ran away at Birmingham Snow Hill

- 115 The rail gear on the TD-18 RRV has rail wheels that are connected to a pivoting steel assembly (Figure 12). As on a Basket 14 RRV, the rail gear is raised and lowered using hydraulic rams; however, no locking pins are required to secure it in place.
- 116 A lever on the cab floor (the *rail gear lever*), to the left of the driver's seat, is used to control lowering and raising. As with the rail gear switch on the Basket 14 RRV, the lever operates one set of rail gear at a time. The *rail gear selector switch* on the driver's console determines whether this is the set at the front or the rear.



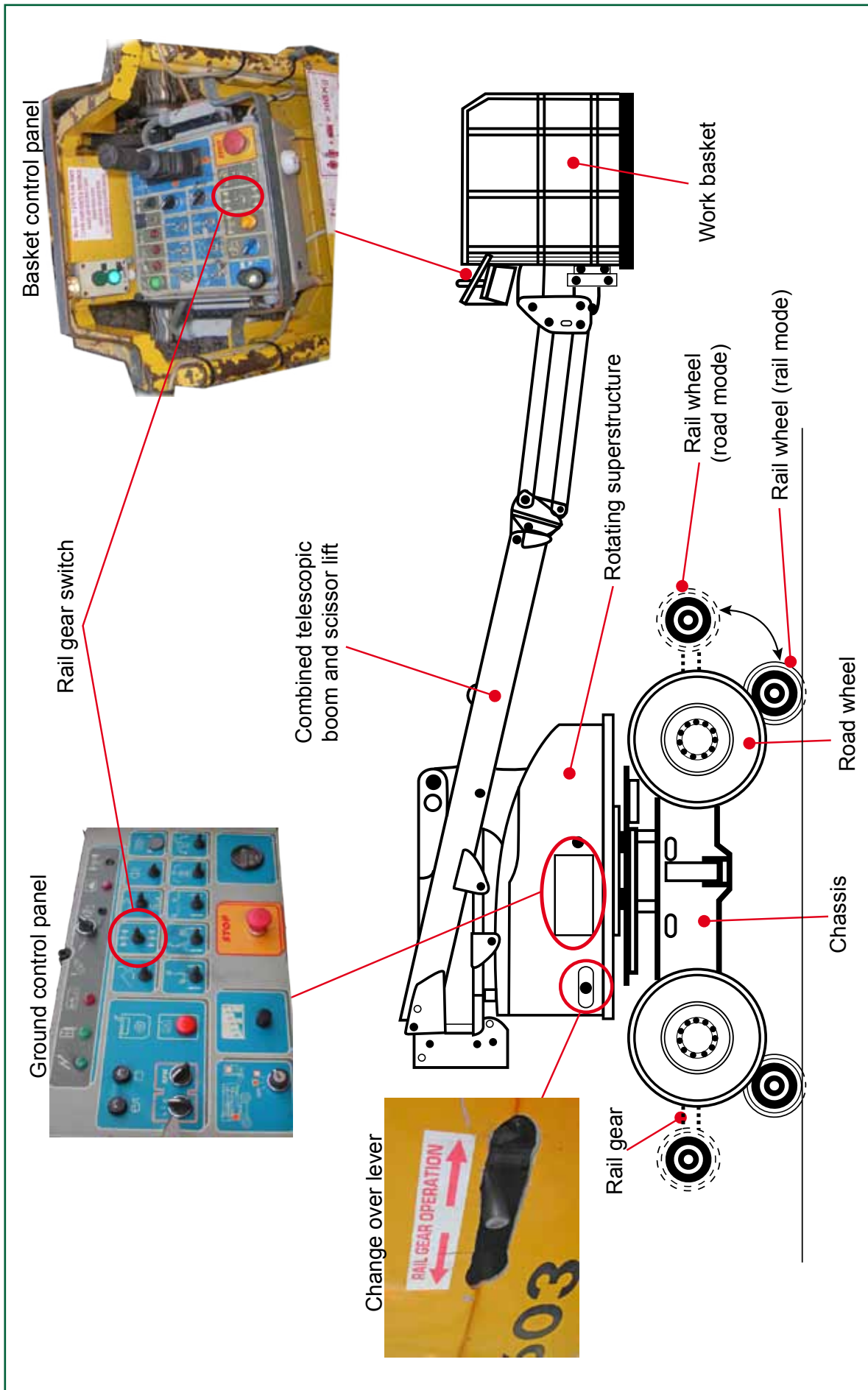


Figure 10: Basket 14 RRV – principal features



Figure 11: Basket 14 RRV - rail gear



Figure 12: TD-18 RRV rail gear at the front of the machine

- 117 There is an emergency stop button in the cab.
- 118 The rear rail wheels are fitted with a parking brake. This brake is only applied when the gear selector is in 'neutral'. The front rail wheels are not fitted with brakes. When the gear selector is **not** in 'neutral', braking in rail mode is the same as on the Basket 14 RRV: it is indirect and reliant on frictional contact between the rail and road wheels.
- 119 Figure 13 shows the arrangement of the above controls. The gear selector is in the 'neutral' position.

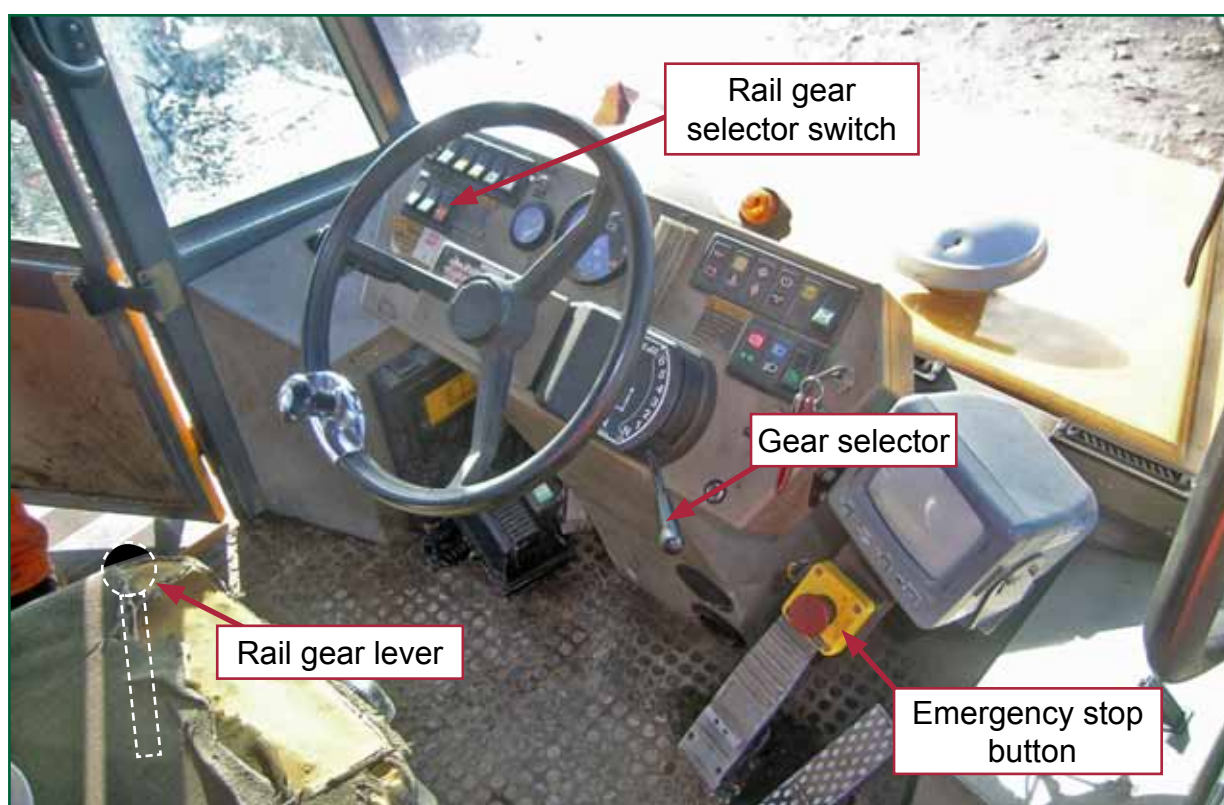


Figure 13: TD-18 RRV controls in the driver's cab

### High ride RRVs – runaway risk during on/off-tracking

- 120 There are three main types of RRV, each characterised by their wheel arrangement in rail mode:
- self-powered type: full weight of the vehicle is supported by rail wheels that are directly driven and braked;
  - low ride type: weight of the vehicle is shared between rail and road wheels, both of which are in contact with the track – only the road wheels are driven and braked; and
  - high ride type: vehicle is raised up and completely supported by rail wheels that are indirectly driven and braked by frictional contact with the road wheels<sup>3</sup>.

Both incidents involved high ride type machines.

<sup>3</sup> There are exceptions to this as some high ride RRVs have supplementary brakes on their rail wheels for parking. The TD-18 is an example, however, its supplementary brake only acts on the rear wheels, and then only when in a particular drive mode.

- 121 High ride RRVs are common in the Great Britain. Published data shows that over 80 % of RRV excavators - a fleet of around 850 - are high ride.
- 122 In road mode, the road wheels on a high ride RRV are in contact with the ground and provide the braking. When lowering the rail gear at one end, while on-tracking to change to rail mode, a transient condition occurs where no braking is provided at that end of the vehicle. This happens because the rail wheels, not yet in contact with the road wheels, contact the rail and lift the road wheels at that end off the ground, Figure 14. The same transient condition occurs while off-tracking, to change to road mode: contact is lost between the rail wheels and the braked road wheels before the road wheels contact the ground.

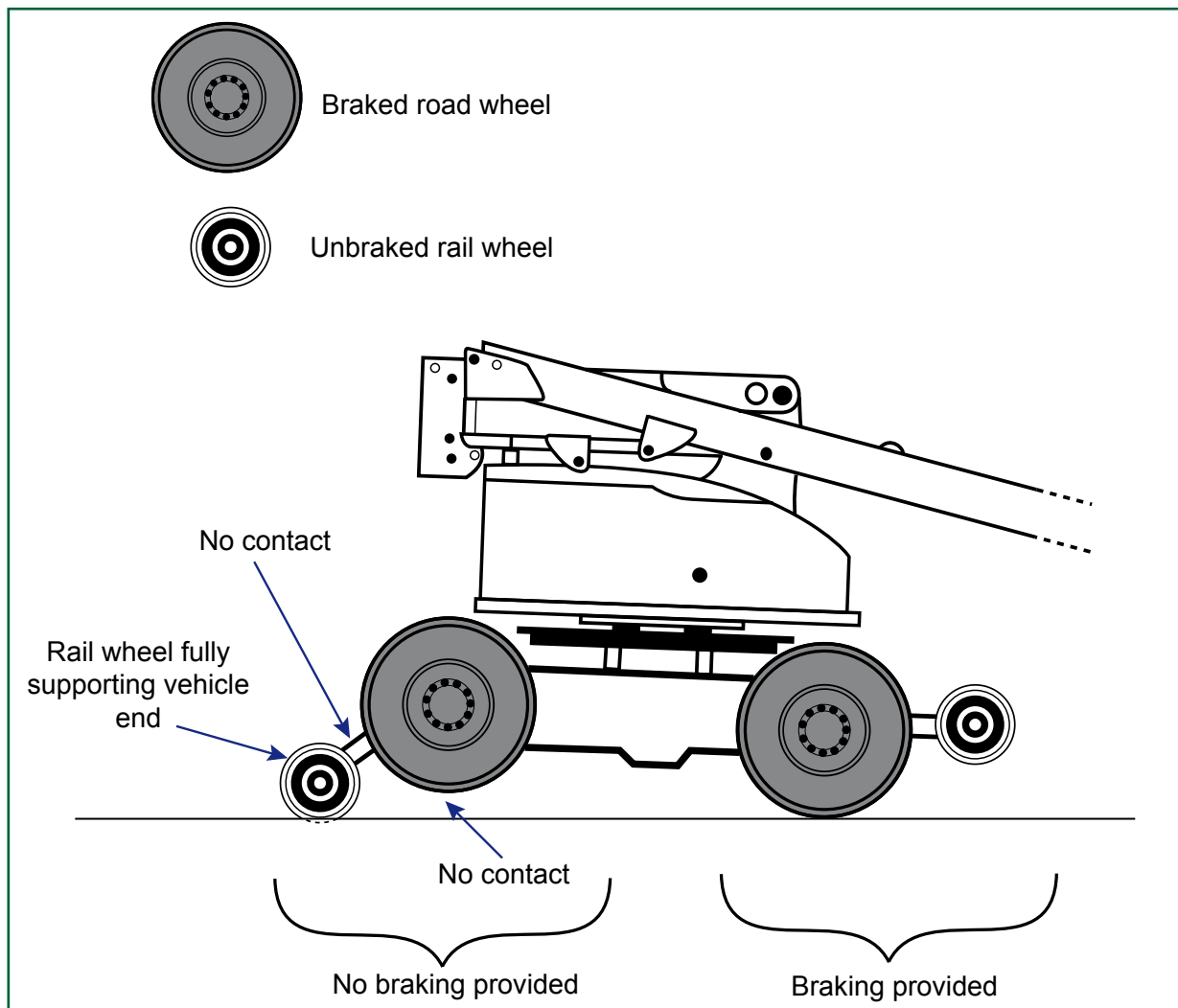


Figure 14: High ride RRV – transition condition that results in no braking being provided at one end of the machine during on/off-tracking

123 This transient condition is an inherent feature of the high ride design. Preventing a runaway condition relies on there being sufficient braking at the other end of the machine (subsequently referred to as the *holding end*) to overcome any gravitational force due to track gradient. If there is no brake force at the holding end, a point is reached, as the rail gear is lowered (or raised), when all braking is lost and, even on a modest gradient, the RRV will start to run away. Two risk conditions exist:

- Risk condition A

The holding end is left in the transient condition with no braking provided (road wheels lifted off the ground, rail wheels not in contact with the road wheels) when the rail wheels at the opposite end are lowered (or raised), Figure 15(a).

- Risk condition B

The road wheels at the holding end are on the ground, and carrying their full load, but the rail wheels were left close to - or just touching - the rail. With reference to Figure 15(b), when the rail wheels at the opposite end are lowered (1), the RRV first tips about the road wheels at the holding end (2), but it then tips about the adjacent rail wheel as it comes into contact with the rail (3). This lifts the road wheels that were providing the braking off the ground (4)<sup>4</sup>.

124 The following control measures prevent the two risk conditions occurring during on/off-tracking :

- a check that at the holding end either:
  - the rail wheels are in full contact with the road wheels; or
  - the road wheels are in full contact with the ground **and** the rail wheels are fully clear of the rail; and
- confirmation that the above state remains until the rail wheels on the opposite end are fully lowered (or raised).

125 Clause D9.1 d) of Railway Group standard GM/RT1300 issue 3, the standard applicable when the Basket 14 RRV was approved for use, required a 'documented system' for on/off-tracking that has been assessed to ensure that 'no inadvertent movement' occurs. The *railway industry standard* that Network Rail now require RRVs to comply with, RIS-1530-PLT 'Engineering acceptance of possession-only rail vehicles and associated equipment', contains an equivalent requirement: clause 5.17.1.1 d). Neither of these standards require RRVs to be fitted with a control system that prevents this 'inadvertent movement', and therefore, at the time of these incidents, it was common to rely on a documented procedure to prevent risk conditions A and B occurring.

## Operator training

126 ETI trains and assesses its RRV operators using courses developed in-house and approved by the *Rail Plant Association*. These are designed to satisfy requirements specified by Network Rail and codes of practice issued by Network Rail's M&EE networking group.

<sup>4</sup> For practical reasons, the rail wheels on high ride RRVs are usually located outboard of the road wheels. This makes them prone to contacting the rail when the RRV tips as the opposite end rises.

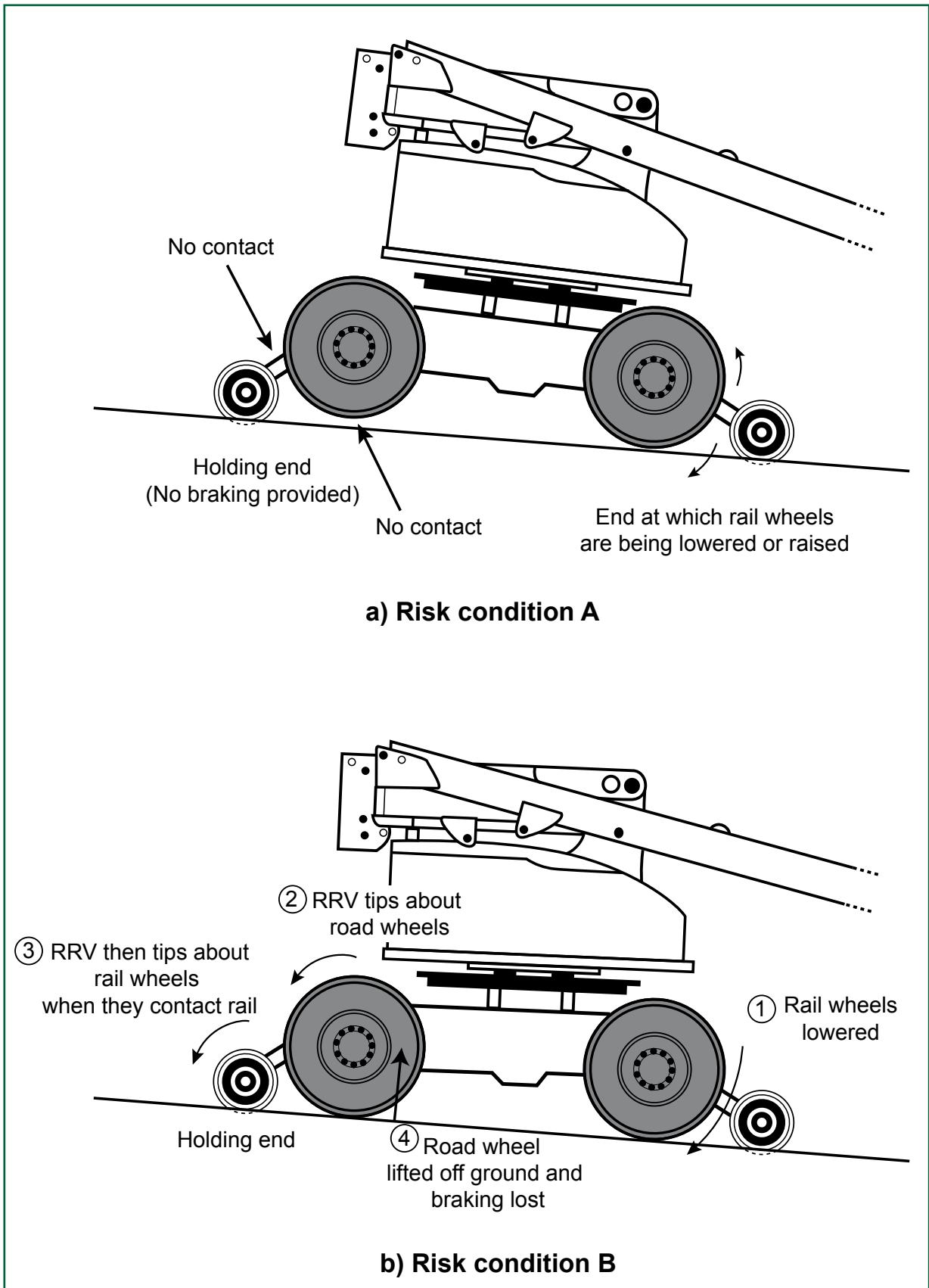


Figure 15: High ride RRV - on/off-tracking runaway risk conditions

- 127 The courses are machine specific, and are of three to four days duration depending on machine type. The first day is spent mainly in the classroom reviewing the relevant theory: machine overview and operation, pre-start checks, documentation and safety issues. The candidates get a course manual written by ETI. The remainder of the course consists of practical sessions using the machine – including on/off-tracking practice. There is a theory test on the final day.
- 128 ETI issues successful candidates with a probationary certificate that may not exceed three months. During this time the operator is led by a mentor. He is not permitted to undertake duties without a mentor until, during the same period, he is assessed by a trainer and a decision is made to replace the probationary certificate with a certificate of competence that is valid for two years.
- 129 ETI re-assesses the competence of qualified operators every two years in their workplace. The certificate of competence issued to the operator involved in the runaway incident at Brentwood (paragraph 30) was issued following a workplace re-assessment on 17 February 2007. The assessor judged him ‘competent’ and raised no concerns.

### Machine controller training

- 130 Network Rail company standard NR/L3/OPS/048/TMMIND, ‘Train Operations Manual Industry Mandatory Section’, requires its contractors and suppliers to manage machine controller competence through the Network Rail Sentinel scheme.
- 131 Machine controller and *crane controller* were introduced as Sentinel competencies in late 2005. Prior to this, training and assessment was on schemes developed and run by employers or by external training providers. Network Rail was concerned about variability in the quality and content of this training, and the recognition and portability of the competence certification. It developed the Sentinel machine and crane controller’s scheme to address this by ensuring that candidates are trained and assessed to nationally-applied standards. The training material is provided by Sentinel and delivered by licensed providers. The *National Competency Control Agency’s* database is used to record and manage the competencies awarded.
- 132 The Sentinel machine and crane controller scheme is modular, reflecting the variety of railway plant in use. Modules are grouped into three levels:
- core competence type: ‘machine controller’, ‘crane controller’ and ‘crane controller-tandem lift’;
  - core machine type: e.g. ‘RRV’ and ‘OTM’(on-track machine); and
  - individual machine type: e.g. ‘MEWP’ and ‘360 excavator’.
- 133 To control a particular machine, a machine (or crane) controller needs to hold the appropriate module(s) at each level. For a Basket 14 RRV or TD-18 RRV , he needs the following: ‘machine controller’, ‘RRV’ and ‘MEWP’. The ‘machine controller’ and ‘RRV’ competence is shown on a plastic identity card that Sentinel issue to him. The ‘MEWP’ competence is shown on a separate counterpart document that Sentinel issue.

- 134 The scheme requires the machine controller to maintain a Sentinel logbook, detailing the machines worked with and the site activity. This is reviewed as part of the re-assessment process.
- 135 The training material for the scheme was developed from employer's schemes that represented good practice. It was validated by the M&EE networking group.
- 136 At the individual machine type level, the training material aims to address the general issues that are common to all machines within the type. A representative machine is used for the practical demonstration of specific training points. Although it was recognised that there were limitations to this approach, it was decided that it would be impractical to provide training on the specifics of every machine make and model within the type. Clause 6.3 of procedure TMM001 of NR/L3/OPS/048/TMMIND requires the employer to manage the competency issues arising from machine variation.
- 137 The machine controller at Brentwood reported that he held this competence for seven years – from before the introduction of the Sentinel machine and crane controller scheme. He did his training and assessment, including refreshers, when working for a former employer. This gave him *grandfather rights* for the Sentinel core competencies of 'machine controller' and 'RRV' and avoided him having to do the associated Sentinel training (but not Sentinel's processes for continual competence assurance and re-assessment). For reasons not significant to the investigation, he was not given grandfather rights for the competence of 'MEWP'. He attended the one day Sentinel training course for this on 10 January 2007 - again when working for a former employer - and was assessed as competent.
- 138 ETI are licensed Sentinel training providers and normally train and assess their own machine controllers. Although the TD-18 RRV machine controller at Birmingham Snow Hill also had grandfather rights, and therefore did not need to have the Sentinel machine controller training, ETI had re-assessed him prior to the incident using the relevant Sentinel material (paragraph 79).
- 139 In August 2007, ETI reviewed the Sentinel logbooks of both machine controllers involved. It recorded the result of both reviews as a 'pass'.

### Previous occurrences of a similar character

- 140 Runaway incidents involving RRVs of the MEWP type have occurred during on/off-tracking at Copley West Junction, Leeds (9 November 2003), Stockport (5 and 17 August 2004) and Copenhagen Tunnel, near London King's Cross (15 October 2006).

#### Copley West Junction, Leeds, 9 November 2003

- 141 On 9 November 2003, two Basket 14 RRVs collided following a runaway near Copley West Junction, Leeds, shortly after being introduced into the UK. The runaway occurred during off-tracking. Rail Access Platforms Ltd owned both machines; they were being used on engineering work carried out by Jarvis Rail Ltd, a Network Rail contractor.
- 142 Jarvis Rail Ltd investigated the incident and concluded that the runaway was due to the operator raising both sets of rail gear at the same time<sup>5</sup>.

<sup>5</sup> National Incident Report (NIR) 1677



- 143 Simultaneous raising of both sets of rail gear was possible because of the way the controls were configured on these first machines. It presented the risk that the transition condition described in paragraph 122 could occur at both ends at the same time - in effect, presenting risk condition A (paragraph 123). Rail Access Platforms Ltd decided to make a change to the hydraulic system of the Basket 14 RRV - involving the valve operated by the changeover lever (paragraph 112) - so that only one set of rail gear could be lowered (or raised) at a time.
- 144 Rail Access Platforms Ltd and the manufacturer's UK-agent modified the Basket 14 RRVs already supplied. Modification of the other machines, including those for ETI, was done during manufacture. The VAB responsible, Interfleet (paragraph 27), assessed the compliance of the modifications and issued revised certificates of engineering acceptance.

#### Stockport, 5 and 17 August 2004

- 145 Two runaway incidents occurred within two weeks of each other, the first was on 5 August 2004 and the other on 17 August 2004, at the same road-rail access point near Stockport. Both involved RRVs that were being used on engineering work carried out by AMEC Spie Rail Ltd, a Network Rail contractor.
- 146 The first incident involved a Gallmac WMW 115, a high ride RRV, which was off-tracking. The machine ran downhill and was stopped short of points at Edgeley Junction by a wooden sleeper that the site team had managed to place on the track. Catena Rail Ltd owned and operated the machine.
- 147 The second incident involved a Genie 45/22, another high ride RRV, which was on-tracking. The machine ran downhill; it was again stopped short of points at Edgeley Junction by obstructions placed on the track. The machine was on hire from Norex Hire Ltd and operated by an ETI employee.
- 148 Network Rail conducted an investigation into these two incidents. In the first incident, the runaway occurred because the rail wheels were not moved (raised) one end at a time as the manufacture's on-tracking procedure required. These findings imply that the runaway was due to risk condition A (paragraph 123).
- 149 For the second incident, the investigation report states that a 'see-saw effect' existed as the machine on-tracked. It resulted in load being transferred from the braked road wheels, which were providing the braking, to the adjacent unbraked rail wheels. These findings imply that the runaway was due to risk condition B (paragraph 123).
- 150 Emergency stop buttons were pressed in both incidents. This did not stop either machine, and, as the operator was unable to lower (or raise) the rail gear, prevented recovery actions that could have re-established braking.

#### Copenhagen Tunnel, London King's Cross, 15 October 2006

- 151 On 15 October 2006, a Basket 14 RRV, which was being on-tracked, ran away for around 500 metres until it derailed and then stopped 30 metres inside Copenhagen Tunnel near London King's Cross. Rail Access Platforms Ltd owned the machine; it was on hire to ETI who were undertaking renewal work on the overhead line equipment in the area. ETI employed the operator and the machine controller.

- 152 The RAIB attended the incident site and conducted a preliminary examination. There was a clear indication of human error. As steps were being taken to improve training in this particular aspect, the RAIB concluded it would not carry out a full investigation. The RAIB wrote to advise ETI of this.
- 153 Network Rail investigated the incident. It found that the rail wheels at the fixed-end were on the track and not in contact with the road wheels when the operator lowered the rail wheels at the steered-end. This finding implies that the runaway was due to risk condition A (paragraph 123).
- 154 The emergency stop button was pressed in the incident. Again, it did not stop the machine and again it prevented the operator being able to re-establish braking.
- 155 The investigation found that the machine controller did not have all the Sentinel competence modules he needed for controlling the Basket 14 RRV. He held the core competencies for 'machine controller' and 'RRV', but not the individual machine type competence for 'MEWP' (paragraphs 132 and 133).
- 156 As well as highlighting this, Network Rail advised ETI that the machine controller should have had an additional assessment on the specifics of the Basket 14 RRV. ETI were not previously aware of this requirement. They had understood that, with the introduction of the Sentinel machine controller scheme, no training or assessment was required over and above that of the Sentinel competence modules. Network Rail drew ETI's attention to the requirements of NR/L3/OPS/048/TMMIND - the relevant requirement is in procedure TMM001, (paragraph 136).
- 157 ETI acted to provide additional training for its machine controllers, both permanent and temporary, on the specifics of their machines - particularly with regard to assisting with the on/off-tracking process. ETI issued company *powered plant proficiency certificates* as proof of the required machine specific competence.
- 158 Network Rail issued a safety briefing to alert operators, machine controllers and other site staff of the issues arising from the incident. ETI delivered this to their staff and also their own briefing, which clarified the procedure for on/off-tracking a Basket 14 RRV.
- 159 Network Rail also set up an industry working group to identify modifications to the Basket 14 RRV that would prevent runaways like those at Copley West Junction and Copenhagen Tunnel. The working group intended that they would later review the runaway risks associated with other types and models of RRV.
- 160 Representatives from Network Rail, ETI, Rail Access Platforms and Interfleet attended the first meeting on 19 December 2006. It was decided that a remote control panel (subsequently referred to as the wander-lead modification) would enable the operator to carry out all required on/off-tracking actions alone. The design of the Basket 14 RRV at the time meant that the operator needed to be in the work basket to operate and drive the machine. Assistance was therefore needed with the parts of the Basket 14 RRV that were only accessible from the ground: the locking pins and the changeover lever (paragraphs 110 and 112). The aim of the wander-lead modification was to give the operator direct access to these.

161 ETI and Rail Access Platforms agreed to investigate the practicality of the wander-lead modification. After meeting on 2 February 2007 and engaging the help of an engineering consultant, they decided to pursue the development of the modification. By early March 2007, the consultant had completed the technical specification. As well as providing the operator with the means of on/off-tracking on his own (from ground level), the proposed design offered the possibility of preventing the operator lowering (or raising) one set of rail gear while the other was in an unsafe state.

## ORR Improvement Notice and consequent action

162 The ORR is the safety regulator for the railway industry in Great Britain and is responsible, amongst other matters, for ensuring compliance with health and safety at work legislation. The ORR conducted its own investigation into the incident at Copenhagen Tunnel and, as result, issued Network Rail with an Improvement Notice on 29 January 2007<sup>6</sup>. The notice required Network Rail to identify those RRVs of MEWP type permitted to operate on its infrastructure that 'have no emergency facilities...to provide a continuous means of braking and stopping in the event of the facility becoming unavailable during the process of on or off raiing'. These RRVs had to be modified or withdrawn. ORR's deadline was 31 December 2007.

163 After receiving the notice, Network Rail wrote to all owners of MEWPs on 9 February 2007. It requested the details of machines at risk of being unbraked during on/off-tracking. However, the response to this was incomplete and Network Rail therefore did their own review of the national fleet; they identified around 80 machines that could be at risk.

164 Network Rail decided that the Improvement Notice terms would be met by mandating that clause 5.17.1.1 d) of RIS-1530-PLT be assured by 'engineering change'. This clause requires that 'no inadvertent movement' occurs during on/off-tracking (paragraph 125). As published, RIS-1530-PLT only requires that a 'documented system' is in place to prevent 'inadvertent movement'. On 16 March 2007, Network Rail wrote to the owners and operators of the at-risk machines requiring them to comply with this mandate by 30 November 2007, a month before the ORR deadline.

165 Network Rail left the detail design of any modification to the owners and operators. A certificate of engineering acceptance, issued by a VAB, was required as proof of compliance; the VAB was expected to review the acceptability of any modification and its implementation.

166 The TD-18 RRV was on the list of at-risk machines when Network Rail wrote to owners and operators on 16 March 2007. However, because the TD-18 RRV's rear rail wheels had a parking brake fitted (paragraph 118), Network Rail accepted ETI's claim that it was already compliant. The TD-18 RRV was removed from the list of at-risk machines and ETI made no modification.

167 The Basket 14 RRVs owned by Rail Access Platforms and ETI were also on the list of at-risk machines. To comply with the Improvement Notice, they decided to continue with the development of the wander-lead modification (paragraphs 160 and 161). A *technical file* was prepared for the VAB to review.

<sup>6</sup> ORR Improvement Notice serial number I/SP4050175/300529125

168 The design developed for the wander-lead modification included:

- a plug-in pendant control box with buttons to drive and steer, and raise and lower the rail gear; and
- electrical sensors and switches to detect the position of the rail gear arms and locking pins.

The pendant control box plugs in next to the set of rail gear that is to be lowered (or raised). The sensors and switches are used to detect if conditions are safe for the pendant to be removed and used with the rail gear at the opposite end. A *logic controller* is used to prevent the two sets of rail gear being operated in certain sequences – in effect, providing an interlock to ensure that braking is always provided at the holding end and so avoiding the occurrence of both risk condition A and B.

169 Interfleet, the VAB for the modification, witnessed prototype testing on one of ETI's Basket 14 RRVs on 23 August 2007. However, a fault condition was identified that resulted in the interlocking function being bypassed.

170 The engineering consultants made improvements and on 7 November 2007 Interfleet witnessed further tests. This was after the runaway incident at Brentwood and, apart from the aforementioned prototype, no other Basket 14 RRVs - including the incident machine at Brentwood - had been modified.

171 Alerted to the fact that locking pins were incorrectly located on the machine at Brentwood (paragraph 70), Interfleet found another fault condition - involving the incorrect insertion of these pins - that could cause the interlock function to be bypassed. Another detection switch was needed to remedy this.

172 All Basket 14 RRVs were finally modified and certified by 22 November 2007 – complying with Network Rail's deadline. Figure 16 shows the wander-lead modification that was fitted.

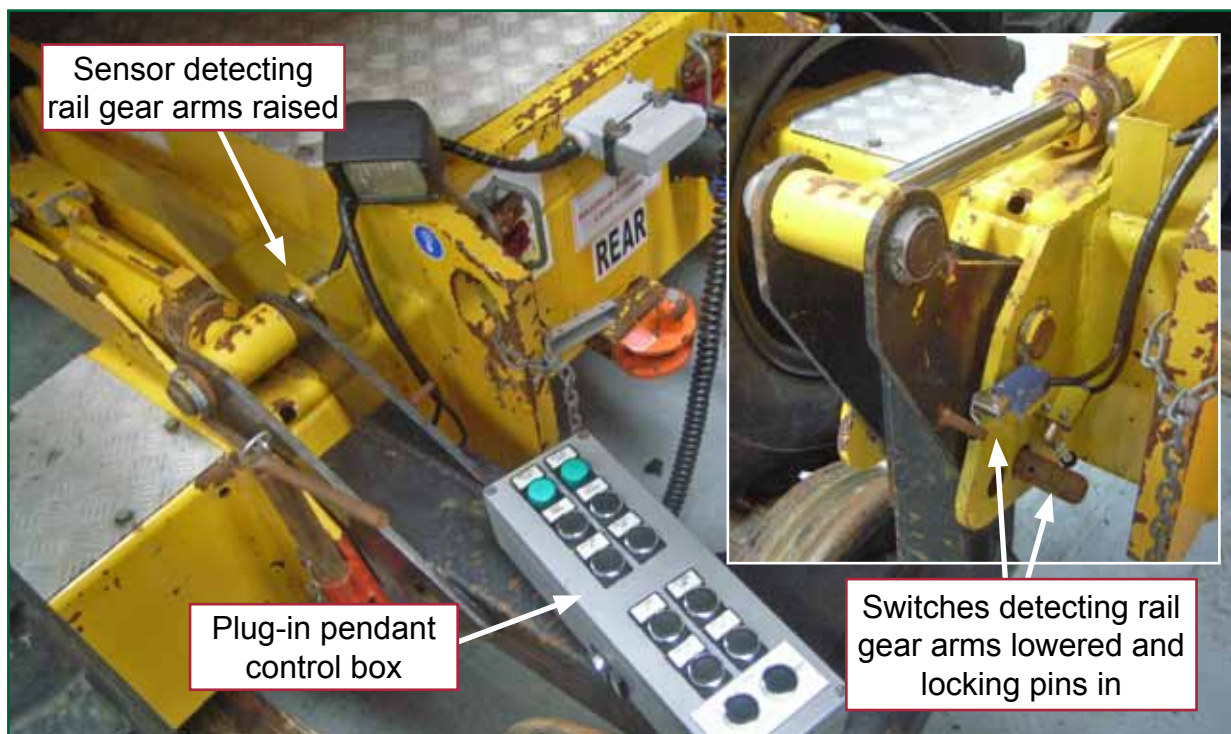


Figure 16: Basket 14 MEWP wander-lead modification

## Analysis

### Identification of the immediate cause<sup>7</sup>

173 The evidence shows that the RRVs at Brentwood and Birmingham Snow Hill ran away as a consequence of two combined risks:

- the RRVs were on significant gradients (paragraphs 35 and 84); and
- the RRVs were both of designs that were prone to loss of braking during the on/off-tracking operation (paragraphs 120 to 123).

In summary, the immediate cause of both incidents was that the RRVs started to run away because of the actions carried out during their on/off-tracking. These resulted in each of the RRVs being put in a condition where their rail wheels carried the full weight of the machine, but were unbraked - by either a direct or an indirect means.

### Identification of causal<sup>8</sup> and contributory<sup>9</sup> factors

174 All braking was lost on the two incident RRVs because in neither case was it ensured that a brake force would remain at the holding end when the rail gear was lowered (or raised) at the opposite end (paragraph 123). To identify the causal and contributory factors for the two incidents, the investigation first considered the reasons for the loss of braking force at the holding end. Consideration was then given to the following measures which could also have prevented an uncontrolled runaway condition developing:

- an engineered interlock – to enforce a sequence of on/off-tracking actions that ensures there is braking force at the holding end when the rail gear is being lowered (or raised) at the other;
- on/off-tracking procedures – similarly, to ensure a braking force at the holding end; and
- emergency action – to re-establish braking after a runaway had started.

#### Loss of braking force at the holding end

##### Incident at Brentwood

175 At Brentwood, the operator was lowering the rail gear at the fixed-end of the Basket 14 RRV when it started to run away. The most likely reason for there being no braking force at the holding end (the steered-end) relates to the position that the locking pins were in when the machine was examined at Romford (paragraph 70).

<sup>7</sup> The condition, event or behaviour that directly resulted in the occurrence.

<sup>8</sup> Any condition, event or behaviour that was necessary for the occurrence. Avoiding or eliminating any one of these factors would have prevented it happening.

<sup>9</sup> Any condition, event or behaviour that affected or sustained the occurrence, or exacerbated the outcome. Eliminating one or more of these factors would not have prevented the occurrence but their presence made it more likely, or changed the outcome.

176 When not located in a hole, the locking pins hang from a length of chain, which attaches them to the chassis of the RRV for safekeeping. When examined at Romford, all the locking pins were in hard contact with the rail gear arms. This suggests that they were in the chassis bracket holes before the rail gear was first lowered at Brentwood; they had possibly been put there for storage or to prevent them swaying about on the chain. With the pins located like this, the rail wheels, carrying the weight of each end of the machine, were prevented from making contact with the road wheels (Figure 17). Therefore, although the machine controller did not observe them, it is almost certain that it was these incorrectly located pins that resulted in there being no brake force at the holding end (steered-end). In this state, the machine was prone to risk condition A (paragraph 123).

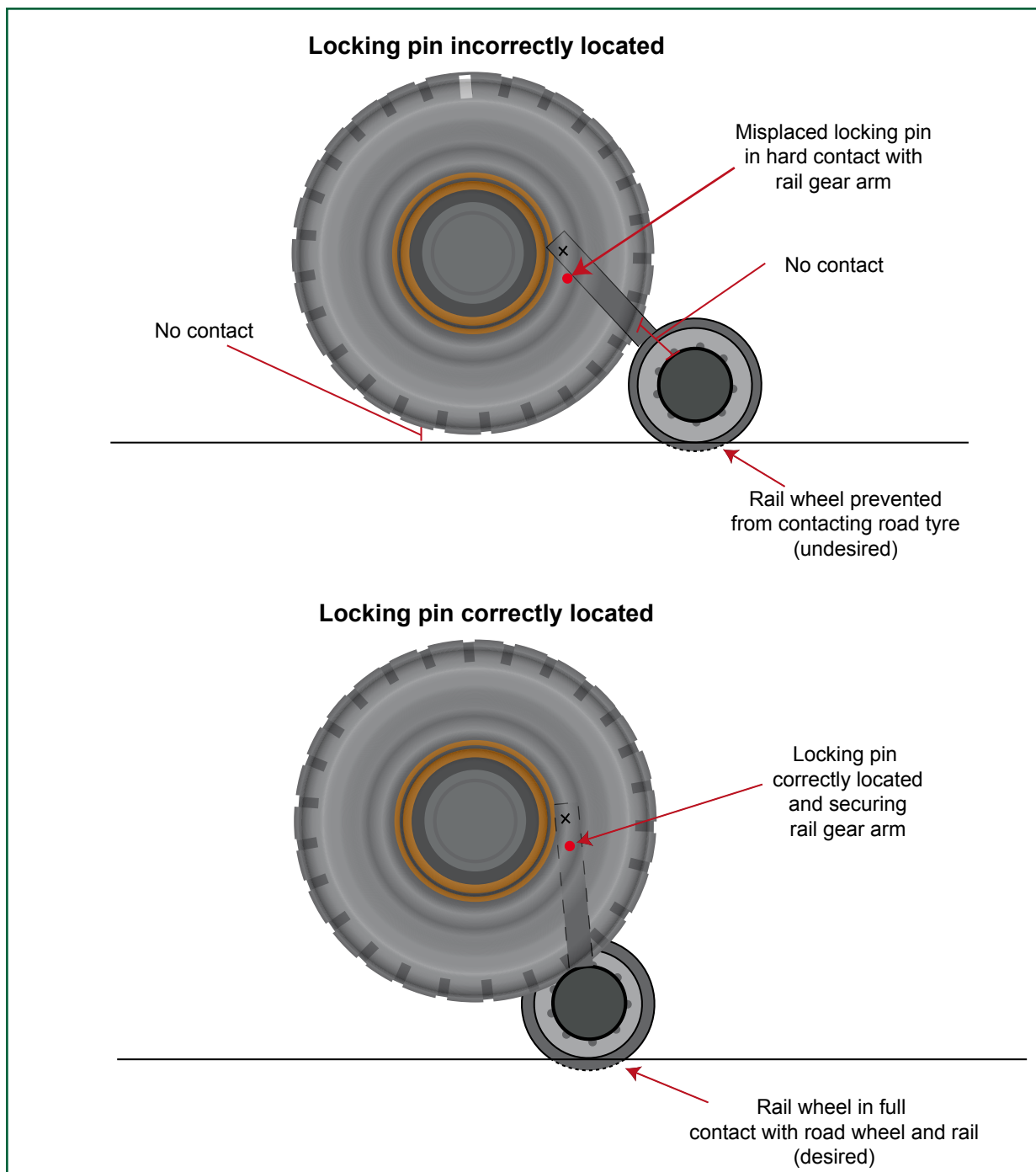


Figure 17: Locking pins incorrectly located and preventing the rail wheels contacting the road wheels

- 177 The fact no-one observed that, because the locking pins were incorrectly located, there was no contact between the rail and road wheels at the holding end (steered-end) before lowering the rail gear at the opposite end was causal to the Basket 14 RRV starting to run away.
- 178 The reported way in which the Basket 14 RRV was on-tracked showed that there were two other means by which braking could have been lost at the holding end. These are possible whether the locking pins are correctly or incorrectly located. They concern a misunderstanding of the position that the rail wheels at the holding end should have been in before the changeover lever was moved:
- The machine controller thought that the operator was locating the wheel flanges between the rails to help him line up the wheels at the opposite end (paragraph 53) and therefore that the operator was not trying to deploy the rail gear fully. The machine controller could therefore have expected the rail wheels to be close to or just touching the rail. This would mean the machine was prone to risk condition B (paragraph 123).
  - The operator did not have a clear view of the holding end, but took an indication from the machine controller, who could see, to mean that the rail wheels were fully down (paragraph 52). This could have stopped him lowering the rail gear when the rail wheels were only partially down, before they contacted the misplaced locking pins and when not in contact with the road wheels, but carrying the full load of that end of the machine. This would mean the machine was prone to risk condition A (paragraph 123).

The physical evidence at Romford suggests that neither of these ultimately led to the loss of braking which caused the runaway. However, in slightly different circumstances they could have.

- 179 In practice, therefore, the locking pins being incorrectly located was only one of three possible means by which braking could have been lost. On-tracking in accordance with the control measures in paragraph 124 would have prevented a runaway developing from all of them.

#### *Incident at Birmingham Snow Hill*

- 180 In the Birmingham Snow Hill incident, the operator, following instructions from the machine controller, was raising the front rail gear on the TD-18 RRV to off-track when it ran away.
- 181 When it had stopped, the machine controller observed a 40 mm gap between the rear rail and road wheels (paragraph 98). There was, therefore, no indirect braking from the road wheels at the holding end and the machine was prone to risk condition A. From the cab, the operator could not see if the rear rail and road wheels were in contact. He required the help of another person – in practice, the machine controller.
- 182 Not checking that there was contact between the rear rail and road wheels before the front rail wheels were raised was causal to the TD-18 RRV starting to runaway. This check is critical to the control measures in paragraph 124.

- 183 The rear rail wheels of the TD-18 RRV have a parking brake (paragraph 118). Tests carried out by ETI afterwards showed that it would have automatically applied if the gear selector had been in 'neutral' (paragraph 103). This shows that the selector was not in 'neutral'; if it had been, the parking brake would have provided a brake force at the holding end. ETI found no evidence to indicate a fault with the parking brake.
- 184 Not ensuring the gear selector was in 'neutral' before raising the front rail wheels was contributory to the TD-18 RRV starting to runaway.
- 185 With the gear selector not in 'neutral', a torque would initially have been transferred from the road wheels to the rail wheels if the cab accelerator pedal was used when raising the rail gear. This may have helped start the TD-18 RRV moving, but would have had no further influence after contact was lost between the rail and road wheels.

#### Engineered interlock

- 186 At the time of the two incidents, there was no engineered system or interlock on either the Basket 14 RRV or the TD-18 RRV that required the rail wheels at one end to be in a certain position before those at the other end could be lowered (or raised).
- 187 During on/off-tracking, an engineered interlock could have ensured that sufficient braking was provided at the holding end by physically enforcing adherence to the control measures in paragraph 124.
- 188 After the incident at Copenhagen Tunnel, the ORR was sufficiently concerned about the braking on MEWP types of RRV during on/off-tracking that they issued an Improvement Notice (paragraph 162). Network Rail's response, in effect, was that all RRVs of this type needed to be fitted with an engineered interlock – unless it could be shown that adequate braking was already provided.

#### Incident at Brentwood

- 189 Basket 14 RRVs were identified as requiring an interlock. In response to Network Rail's earlier concerns, Rail Access Platforms Ltd and ETI were already developing the wander-lead modification. They decided to continue with this development, incorporating an interlocking function.
- 190 The wander-lead modification was still being developed when the runaway happened at Brentwood, and it was only because of this incident that a design improvement was identified to ensure that the interlock would work if the locking pins were incorrectly located (paragraph 171). However, as the operator would be in close proximity and able to immediately find and remove any incorrectly located pins, even without this improvement the wander-lead modification should have been effective in ensuring adequate braking was provided.
- 191 In summary, although Network Rail's deadline of 30 November 2007 for the modification of at-risk MEWPs had not been passed (paragraph 164), if the Basket 14 RRV had been fitted with the version of the wander-lead modification that was being considered at the time, it is unlikely that it would have runaway at Brentwood.



### Incident at Birmingham Snow Hill

- 192 The TD-18 RRV was on Network Rail's original at-risk list machines and, therefore, potentially required an engineered interlock. However, after considering ETI's claims regarding the parking brake on the rear rail wheels, Network Rail later decided to remove it from the list (paragraph 166).
- 193 The decision to remove the TD-18 RRV from the at-risk list, and therefore exempt it from requiring an engineered interlock, is contributory to it running away at Birmingham Snow Hill.

### On/off-tracking procedure

- 194 As neither of the RRVs had been fitted with an engineered interlock at the time of the incidents, the on/off-tracking procedure, and its correct execution, was critical to avoiding there being no braking provided. Reliance on this procedure is common practice with high ride RRVs. Neither Railway Group standard GM/RT1300 nor its replacement, RIS-1530-PLT, require anything more.
- 195 Railway Group standard GE/RT8000/OTP, the *Rule Book* module for *on-track plant*, defines the operator as the 'person competent' to use on-track plant, in this case, an RRV. As on/off-tracking demands machine-specific competency, it is the operator who most needs to understand the procedure and ensure that it is followed.
- 196 At the time of the incident, the operators of both RRVs needed assistance with on/off-tracking:
- on the Basket 14 RRV, the operator needed to be in the work basket to drive, steer and operate the rail gear switch; another person needed to be on the ground - to operate the changeover lever, advise when road and rail wheels were in contact, and insert (and remove) the locking pins; and
  - on the TD18-RRV, the operator needed to be in the cab to drive, steer and operate the rail gear lever and selector switch; another person needed to be on the ground to advise when the road and rail wheels were in contact and to insert pins to lock the steering mechanism.
- 197 The RAIB investigated three scenarios to understand the causal factors associated with the on/off-tracking procedure:
- on site, the operator and the person assisting him establishing, and agreeing, a set of co-ordinated on/off-tracking actions;
  - prior to arriving on site, the operator and the person assisting already having established, and agreed, the set of co-ordinated on/off-tracking actions; and
  - modifications being considered that would have enabled the operator to on/off-track without assistance.

The following three sub-sections present the findings of this investigation for the incident at Brentwood. After these, the findings for Birmingham Snow Hill are presented.

- 198 In both incidents, the machine controller was the person assisting. It need not have been, but for practical reasons this is common: the machine controller needs to be near the RRV and it is reasonable, providing his own duties are not compromised, that he helps.

*Incident at Brentwood - co-ordinated on/off-tracking actions agreed on site*

199 The RAIB found four different documented procedures for on/off-tracking a Basket 14 RRV:

- the one given to the VAB when it formally approved and assessed the on/off-tracking procedure against GM/RT1300 (paragraph 125);
- two in different versions of the operator's manual: ETI's and Rail Access Platform Ltd's;
- the one described in ETI's operator's training course manual (paragraph 127).

200 All four documented procedures defined a set of detailed tasks. Despite this, although each was different in detail, each set of tasks addressed the most essential parts of the control measures in paragraph 124. However, none was fully compliant with the control measures, and none described the responsibility split between the operator and person assisting. Furthermore, no procedure described how the set of tasks aimed to prevent an unbraked condition, for instance, by showing how they satisfied the control measures. A knowledge of this could have reinforced the operator's understanding of the principles on which the procedure is based and the risks of deviating from it.

201 Before starting work on site, the operator could have agreed with the machine controller which of the documented procedures he was going to use to on/off-track at Brentwood – each was similarly effective. Alternatively, he could have agreed a set of actions that fully and directly addressed the control measures. However, there was no evidence that he had received any training or briefing on these measures.

202 The operator came to no prior agreement with the machine controller; there are a number explanations for this:

- nothing on his list of pre-work checks (paragraph 46) or in his training specifically required him to reach an understanding with the machine controller;
- nothing on the machine controller's list of pre-work checks (paragraph 47) or on the Basket 14 RRV's certificate of engineering acceptance (the normal way of alerting operators of any machine specific restriction) acted as a reminder of the need to reach an understanding;
- although clause 9.4 of Railway Group standard GE/RT8000/OTP requires the machine controller and operator to 'reach a clear understanding' prior to moving an RRV on the track, there is no equivalent requirement for on/off-tracking;
- the operator had worked with the machine controller on around 20 previous occasions, and had successfully on/off-tracked Basket 14 RRVs before; he may therefore have felt that an adequate understanding was already established;
- it is likely that the operator considered that the machine controller (who had less experience of the Basket 14 RRV) was in overall charge and was looking to him to lead the on/off-tracking operation; there is a variety of evidence supporting this, including that:
  - the machine controller is trained to brief the operator, verify his competence and fitness to work, confirm that he has done his machine checks, authorise him to on-track and guide him driving the RRV to the road-rail access point;

- before the introduction of the Sentinel scheme for machine controllers (paragraph 131), ETI required that their machine controllers were first qualified as operators; the operator would have been familiar with this competence hierarchy; and
  - on his practical assessment during training, the operator was required to follow instructions and directions given by a machine controller.
- 203 The number of different documented procedures for on/off-tracking a Basket 14 RRV, and the lack of clarity of role and responsibility, could explain the confusion and misunderstanding that existed when the machine was being on-tracked. The machine controller thought that the operator was trying to locate the wheels at the holding end, whereas the operator had understood that the wheels were all the way down and that he had been instructed, and was therefore safe, to lower the rail gear at the opposite end.
- 204 The operator and machine controller not reaching an understanding regarding the tasks to be performed was causal to the Basket 14 RRV starting to runaway.
- 205 The importance of the on/off-tracking procedure was highlighted in two briefings given after the Copenhagen Tunnel incident: one from Network Rail, the other from ETI. The operator at Brentwood received these briefings on 12 November and 22 October 2006 respectively. The ETI briefing clarified how they required Basket 14 RRVs to be on/off-tracked, in effect, to the procedure in the training course manual (paragraph 199). Neither briefing covered assistance with on/off-tracking. The briefing on Network Rail standard NR/L2/RVE/0007, 'Specification for on and off-tracking of Road-Rail vehicles', that was given to both the operator and machine controller on 4 November 2007 (paragraph 45) related mainly to infrastructure arrangements at the road-rail access point and the risk of overturning and derailment. It did not cover the on/off-tracking procedure or the risk of a runaway.

*Incident at Brentwood - co-ordinated on/off-tracking actions established before site*

- 206 The operator had been formally trained on the on/off-tracking procedure that ETI required him to use (paragraph 205), and although not defined in the course manual, the role of the person assisting (the machine controller) was acted out in the practical sessions. If the machine controller had also received training on the required procedure, and his role in carrying it out, he could have assisted the operator so that they could have safely on-tracked the Basket 14 RRV without depending on prior discussion.
- 207 The machine controller held the correct set of Sentinel competencies for controlling a Basket 14 RRV (paragraph 137). However, Network Rail clarified that it designed Sentinel competencies only to ensure that machine controllers can carry out their duties as defined in the Rule Book. They do not cover any aspects of machine operation, such as assisting the operator with on/off-tracking actions.

- 208 After the incident at Copenhagen Tunnel, ETI, acting on Network Rail's advice, gave additional training to its machine controllers so that they could also help operators with on/off-tracking Basket 14 RRVs. ETI issued powered plant proficiency certificates to show this (paragraphs 156 and 157). ETI incorrectly understood that clause 6.3 of procedure TMM001 of Network Rail company standard NR/L3/OPS/048/TMMIND, 'Train Operation Manual Industry Mandatory Section', was what required it to provide this additional training (paragraph 136). Clause 6.3 requires the employer to manage competency issues arising from machine variation, but this is only so that machine controllers can carry out their Rule Book duties, such as ensuring an RRV is not foul of an adjacent running line. Apart from a general requirement to have processes in place for the competency management of operators and machine controllers<sup>10</sup>, the RAIB found no railway industry specification or procedure that specifically mandated the additional training that ETI gave to their machine controllers so they could assist with on/off-tracking.
- 209 The machine controller at Brentwood was not given additional training for the Basket 14 RRV and did not hold a powered plant proficiency certificate. ETI employed him on a casual basis and, although on its list of approved agency staff, the need for this training was missed - he had been with ETI for two months. He was not aware that he needed this additional training, and there was nothing in the Sentinel training plans to suggest that he should have been. The operator, or a supervisor on site, could have noticed that the machine controller did not hold a powered plant proficiency certificate, but no-one did. There is nothing in ETI's processes or procedures that alerts the operator to check for this certificate. The same issues are unlikely to have arisen before the Sentinel scheme introduction. Then, ETI machine controllers also needed to be qualified operators, and therefore already competent with the specifics of on/off-tracking.
- 210 An inspection of the machine controller's Sentinel card, his counterpart document and the experience documented in his logbook would not have suggested that he should not assist the operator with on-tracking at Brentwood. The general lack of awareness of the scope associated with the Sentinel competencies held by the machine controller and the risks that this posed to assisting with on-tracking the Basket 14 RRV was contributory to the machine starting to move and then running away.
- 211 Prior to the Copenhagen Tunnel incident, ETI did not realise that machine controllers holding Sentinel competencies needed any additional training and assessment. It is possible that there are other organisations operating RRVs who do not realise this.

*Incident at Brentwood - Modifications to allow the operator to on/off-track without assistance*

- 212 A modification to the Basket 14 RRV could have enabled the operator to on/off-track alone, avoiding the risk of task and competence confusion. Network Rail, ETI and Rail Access Platforms Ltd recognised the benefits when they decided to pursue the wander-lead modification on 19 December 2006 (paragraph 160).

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<sup>10</sup> Rail Industry Standard RIS-1700-PLT, 'Rail Industry Standard for Safe Use of Plant for Infrastructure Work'

213 At time of the incident at Brentwood, the wander-lead modification was still in development but had the functionality necessary so the operator would have been able to on/off-track by himself. If it could have been fitted, this would have avoided the need for two people to on-track the Basket 14 RRV - significantly reducing the risk of a runaway.

#### Incident at Birmingham Snow Hill

214 At Birmingham Snow Hill, the operator and the machine controller were both experienced and were trained by ETI (paragraphs 78 and 79). They had successfully on/off-tracked the TD-18 RRV on many previous occasions and should have been very familiar and practised in their respective roles. Therefore the issue, at Brentwood, of reaching a common understanding regarding on/off-tracking actions was unlikely to be as significant. Similarly, neither should the issue relating to the competence certification of machine controllers be significant - the machine controller involved had received ETI's additional training on the specifics of their machines (paragraph 157).

215 An important issue at Birmingham Snow Hill was the parking brake fitted to the rear rail wheels of the TD-18 RRV. In responding to the ORR Improvement Notice, ETI had already claimed that this brake meant the TD-18 RRV could not be unbraked during on/off-tracking. It is possible that the operator and the machine controller were of the same mind and, unaware that the parking brake had not automatically applied because the gear selector was not in 'neutral' (paragraph 183), did not see the need to check for contact between the rear rail and road wheels.

216 No evidence was found in the operator's training course manual, or elsewhere, that during the on/off-tracking operation a check for contact between the rail and road wheels was required, or that there was a requirement that the gear selector should be in 'neutral'. This could partly explain the causal and contributory factors identified in paragraphs 182 and 184.

217 The incident at Birmingham Snow Hill highlights the risks of over-reliance on engineered systems to protect against operational error. Engineered interlock systems, like those enforcing sequenced on/off-tracking actions, can fail or become unknowingly disabled. Adherence to a documented on/off-tracking procedure that meets the control measures in paragraph 124, particularly when the operator needs assistance, would provide a parallel safeguard.

218 The design of the TD-18 RRV, particularly the need for the operator to be in the cab to steer, means that significant modification would be needed to enable the operator to on/off-track on his own. Such a modification would be impractical and there was no evidence that one was being considered.

#### Emergency action - re-establishing braking

219 If the operator and machine controller, working together, had managed to re-establish braking on the two RRVs the initial inadvertent movement could have been prevented from developing into an uncontrolled runaway.

### Incident between Brentwood and Romford

220 At Brentwood, there were two opportunities to re-establish braking:

- continue lowering the rail gear at the steered-end to gain rail and road wheel contact; or
- raise it, to bring the road wheels back onto the ground.

221 Both the operator and machine controller understood what they needed to do, and the operator first tried to lower the rail gear. He could not because the rail gear arms had come into hard contact with the locking pins that were in the chassis bracket holes (paragraph 70).

222 The RAIB found no evidence that the risk of the locking pins being incorrectly located was appreciated before the incident. There was therefore no understanding that either a check or a modification was needed to guard against it. The risk that the locking pins presented to the wander-lead modification was only found after the Brentwood incident (paragraph 170).

223 In the high-stress situation that developed as the runaway started, the machine controller pressed the emergency stop button. It is likely his action was instinctive rather than considered.

224 The stop button cut the engine and, as a result, the hydraulic power. This prevented the operator being able to raise the rail gear – the only remaining opportunity he had to re-establish braking. The operator was unsure of how to re-start the engine from the work basket and therefore did not do so. The machine controller had had no training in starting the engine and, therefore, also did not attempt to re-start it. The emergency stop button was depressed when the RAIB examined the Basket 14 RRV at Romford (paragraph 70). Despite this, the machine controller was confident he had managed to unlatch the stop button after realising his error. Although he could have been successful in doing this – the button being re-pressed by others in the meanwhile, for instance in the attempts to stop the Basket 14 RRV at Romford – this action alone would not have restarted the engine.

225 The emergency stop button, and its functionality, is a requirement of European standard EN280. Previous RRV runaway incidents, for example at Stockport and Copenhagen Tunnel, have highlighted the same risk with its use (paragraphs 150 and 154). So far, attempts to address this risk have been through training and briefing the learning points<sup>11</sup>.

226 From the above it is possible to identify two contributory factors preventing braking being re-established:

- a. not previously appreciating the risk of incorrectly located locking pins preventing the rail arms lowering, and therefore not putting mitigation measures in place; and
- b. the machine controller's decision to press the emergency stop button, which resulted in the hydraulic power being cut.

<sup>11</sup> Network Rail Trainer's Plan for Machine Controller-RRV (Module 9) and Network Rail Projects and Engineering Safety Bulletin 21, dated 26 October 2006.

### Incident at Birmingham Snow Hill

- 227 At Birmingham Snow Hill, the proximity of the parked Basket 14 RRV probably meant there was only one opportunity to re-establish braking: re-lower the rail gear at the front and re-gain contact between the rail and road wheels.
- 228 A high-stress situation developed as people shouted at the operator to stop. He had tried the footbrake and then to reverse – there was no response from the machine. He probably had little time to consider anything else before he jumped clear (paragraph 96).
- 229 Having insufficient time to evaluate the correct course of action was contributory to the TD-18 RRV operator not being able to re-establish braking and stop before colliding with the Basket 14 RRV.

### Observations

- 230 Neither the operator nor the machine controller was aware of the gradient severity at the Brentwood road-rail access point. At Birmingham Snow Hill, ETI's investigation report stated that, visually, the track at the road-rail access point 'seemed level'. The gradient was significant at both locations (paragraph 173). The RAIB found no evidence that this was identified when the work at either Brentwood or Birmingham Snow Hill was planned, for instance as part of the requirements of Network Rail company standard NR/L2/RVE/0007.
- 231 If those on site had known what the gradient was they could have checked to see if it exceeded any restrictions imposed for on/off-tracking – restrictions are stated on the certificate of engineering acceptance that is kept on each RRV – and, if it did, could have taken special precautions. (A Network Rail briefing issued after the Copenhagen Tunnel incident stated the use of timber baulks placed on the track if it is considered that there is a risk of an uncontrolled runaway – that is, if the gradient is too steep.) Alternatively, they could have decided not to use that particular road-rail access point.
- 232 No restrictions with respect to gradient for on/off-tracking were found on the certificates of engineering acceptance relating to either the Basket 14 RRV or the TD-18 RRV. Therefore, no special precautions were required. In spite of this, a knowledge of the gradient severity on the site, if it had been available, could have alerted the teams on/off-tracking at both Brentwood and Birmingham Snow Hill of how quickly an uncontrolled runaway would develop if an unbraked condition was allowed to occur, and therefore that additional vigilance was required.

### Summary of the event chain

- 233 Figure 18 is an overview of the identified causal and contributory factors for both incidents, showing their relationship to the chain of events.

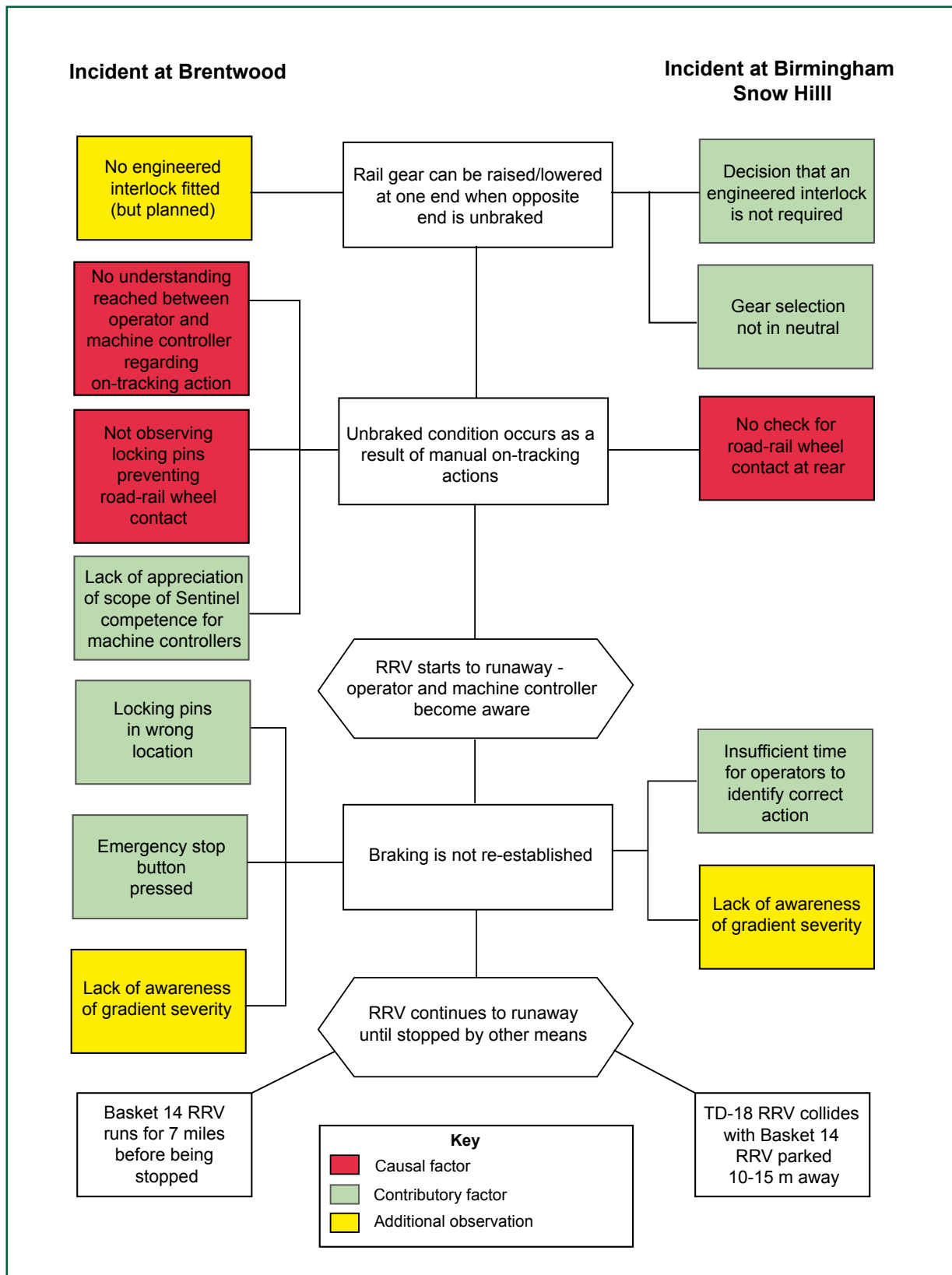


Figure 18: Diagram showing chain of events and causal factors for the incidents at Brentwood and Snow Hill



## Conclusions

### Immediate cause

234 The immediate cause of both incidents was that the RRVs started to run away because of the actions carried out during their on/off-tracking. They resulted in each of the RRVs being put in a condition where their rail wheels carried the full weight of the machine, but were unbraked - by either a direct or an indirect means (paragraph 173).

### Causal factors

235 The following factors were causal to the incident at Brentwood:

- a. During on-tracking, not observing that, because the locking pins were incorrectly located, there was no contact between the rail and road wheels at the holding end (steered-end) before the rail gear was lowered at the opposite end (paragraph 177); and
- b. On site, and before starting to on-track, the operator did not reach an understanding with the machine controller regarding the specific actions each were going to take. No procedure or training specifically required this (paragraph 204).

236 The following factor was causal to the incident at Birmingham Snow Hill:

- a. During off-tracking there was no check for contact between the rear rail and road wheels before deciding to raise the front rail gear. No training was identified that specifically required this (paragraph 182).

### Contributory factors

237 The following factors were contributory to the incident at Brentwood:

- a. The general lack of awareness of the scope of the Sentinel competencies held by the machine controller, and that although they showed he was competent to control the Basket 14 RRV they did not show that he could assist the operator with on-tracking it. It is possible there are other organisations operating RRVs that do not realise that machine controllers may need additional training so they can assist with on/off-tracking (paragraph 210).
- b. No previous appreciation that incorrectly located locking pins on a Basket 14 RRV can prevent braking being re-established, because the rail gear arms cannot fully lower, and therefore, that no mitigation measures were implemented to address this risk (paragraph 226a).
- c. The machine controller's decision to press the emergency stop button, which prevented braking from being able to be re-established because hydraulic power was cut (paragraph 226b).

238 The following factors were contributory to the incident at Birmingham Snow Hill:

- a. the decision that an interlock was not needed in the rail gear deployment system of a TD-18 RRV in response to the Improvement Notice issued by the ORR (paragraph 193);
- b. during off-tracking it was not ensured that the gear selector was in 'neutral' (paragraph 184); and
- c. the operator of the TD-18 RRV having insufficient time to decide the correct course of action for re-establishing braking (paragraph 229).

### **Additional observations<sup>12</sup>**

239 There was a general lack of awareness by those on site of the gradient severity at the road-rail access point, the resulting rate at which a runaway situation could develop during on/off-tracking if an unbraked condition occurred, and therefore that additional vigilance was required (paragraph 232). This observation is relevant to both incidents.

240 If, by 4 November 2007, the Basket 14 RRV at Brentwood had been fitted with the wander-lead modification that was being considered in response to the ORR's improvement notice, it is unlikely that it would have run away (paragraph 191).

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<sup>12</sup> An element discovered as part of the investigation that did not have a direct or indirect effect on the outcome of the accident but does deserve scrutiny.

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

- 241 Because of the incident at Birmingham Snow Hill, ETI has now fitted an engineered interlock to the system that deploys the rail gear on the TD-18 RRV. The modification was verified and certified by Interfleet.
- 242 ETI and Rail Access Platforms Ltd have fitted the wander-lead modification to all their Basket 14 RRVs (paragraph 172). Amongst other issues, this has directly addressed the risks associated with the locking pins being incorrectly located during on/off-tracking.
- 243 ETI and Rail Access Platforms have developed a common procedure for on/off-tracking their Basket 14 RRVs now that they have fitted the wander-lead modification. ETI has trained their staff in the new procedure and has produced laminated cards that are to be kept on its machines to remind them of it.
- 244 All the other RRVs that were on Network Rail's list of machines at risk have been modified or prohibited. The ORR has written to Network Rail to confirm that it is satisfied that Network Rail has complied with the Improvement Notice that was issued following the incident at Copenhagen Tunnel.
- 245 Network Rail is reviewing changes to rail industry standard RIS-1530-PLT with the RSSB to address a potential requirement conflict with EN280 regarding the emergency stop button and the implications of using it during RRV runaways.
- 246 On 14 November 2007, ETI issued a briefing to their staff regarding the company's duty to notify the RAIB of accidents and incidents.

## Completed actions which address factors in the report so avoiding the need for the RAIB to issue a recommendation

- 247 The RAIB has made no recommendation regarding the contributory factor in paragraph 237b, nor the observation in paragraph 240. These have been addressed by the modification made in response to the ORR Improvement Notice (paragraph 242).

248 The following safety recommendations are made<sup>13</sup>:

### Recommendations to address causal and contributory factors

The following recommendation was made by the RAIB as a result of the investigation into an RRV runaway at Glen Garry on 5 December 2007 (Recommendation 5, RAIB report 05/2009<sup>14</sup>):

*'Network Rail should enhance the Sentinel On-Track Plant documentation for RRV operator training to include advice to trainee operators on:*

- *operating on gradients;*
- *operating in low adhesion conditions; and*
- *what to do in a braking emergency.'*

This recommendation addresses the factor identified in paragraph 238c. It is therefore not remade so as to avoid duplication.

1. Network Rail should require all organisations that are permitted to use high ride RRVs on its infrastructure to identify those machines that require the operator to be assisted by another person(s) during on/off-tracking<sup>15</sup>, and to enhance their procedures so that (paragraph 235b):
  - for each machine, the operator is made aware that he needs assistance before he starts working with the machine; and
  - operators are aware of the need to come to a clear understanding with the person(s) assisting them before starting to on/off-track; this understanding should include, but not necessarily be limited to, the steps to be gone through, who is responsible for each step, and the clear and unambiguous communication that is to be used so that the RRV can be safely on/off-tracked.

*continued*

<sup>13</sup> 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 167 to 171) can be found on RAIB's web site at [www.RAIB.gov.uk](http://www.RAIB.gov.uk).

<sup>14</sup> RAIB reports are available at the RAIB web site, [www.RAIB.gov.uk](http://www.RAIB.gov.uk)

<sup>15</sup> In these recommendations, assistance means that to safely on/off-track the RRV the operator needs the help of a person (or persons) to carry out duties that are in addition to those defined for a machine controller in the Rule Book.

2. Network Rail should require all organisations that are permitted to use high ride RRVs on its infrastructure to review their procedures for on/off-tracking and also the supporting training given to their operators. If necessary, organisations should enhance their procedures and training so that (paragraphs 235a, 235b, 236a, 237a and 238b):
  - the defined steps their operators need to go through during on/off-tracking result in a brake force sufficient to prevent the RRV running away on the maximum gradient permitted for on/off-tracking, and that this force is consistently applied at the holding end of the RRV (the end of the RRV that is opposite to the end at which the rail gear is being lowered (or raised));
  - the operator understands his responsibilities for following these defined steps and how the steps assure the braking condition described above; and
  - that if assistance<sup>15</sup> is required:
    - the respective roles of the operator and the person(s) assisting (machine controller or otherwise) are identified for each step; and
    - any special training and competency requirements for the person(s) assisting are identified and implemented, and that the operator understands his responsibilities for checking such competencies.
3. Network Rail should enhance the relevant modules of the Sentinel training so that machine controllers (paragraphs 235a, 235b and 236a):
  - are aware that operators need to come to an understanding with any person assisting<sup>15</sup> them with on/off-tracking; and
  - understand the control measures that prevent an unbraked condition occurring during on/off-tracking.
4. Network Rail should enhance the relevant modules of training given as part of the Sentinel machine controller competency scheme so that those persons holding this Sentinel competency are aware of the specific duties they should be competent to perform and any specific tasks, for example assisting<sup>15</sup> the operator with on/off-tracking, that this competency does not cover (paragraph 237a).
5. Network Rail should enhance the relevant modules of Sentinel training for machine controllers to give guidance and practical training on the actions to be taken in the event of a runaway (paragraph 237c).
6. Network Rail should review the MEWPs that were not modified as a result of the ORR Improvement Notice issued following the incident at Copenhagen Tunnel on 15 October 2006. If necessary, Network Rail should require that enhancements are made to these MEWPs so that they are not at risk of being in an unbraked condition during on/off-tracking (paragraph 238a).

**Recommendations to address other matters observed during the investigation**

The following recommendation was made by the RAIB as a result of the Glen Garry investigation (Recommendation 1):

*'Network Rail should publish the gradient of lines in an easily accessible way, for example in the sectional appendix and at track access points'*

This recommendation addresses the observation in paragraph 239. It is not therefore remade so as to avoid duplication.

## Appendices

### Appendix A - Glossary of abbreviations and acronyms

COSS	Controller of site safety
ETI	Elec-Track Installations
IECC	Integrated electronic control centre
MEWP	Mobile elevating work platform
OLE	Overhead line equipment
ORR	Office of Rail Regulation
OTM	On-track machine
PICOP	<i>Person in charge of possession</i>
RRV	Road-rail vehicle
RSSB	Railway Safety and Standards Board
VAB	Vehicle acceptance body

## Appendix B - Glossary of terms

All definitions marked with an asterisk, thus (\*), have been taken from Ellis' British Railway Engineering Encyclopaedia © Iain Ellis. [www.iainellis.com](http://www.iainellis.com)

360 excavator	Construction machine with an excavating attachment fitted to a superstructure that can rotate through 360 degrees or more.
Basket control panel	The control panel on a Basket 14 RRV that is located in its work basket.
Certificate of engineering acceptance	A certificate, issued by a vehicle acceptance body, recording that a vehicle meets the required standards and gives any necessary operating restrictions.
Certificate of conformance for vehicle maintenance	A certificate recording that the maintenance plan for a vehicle conforms to required standards.
Changeover lever	The control lever on the Basket 14 RRV that determines whether the rail gear at the fixed-end or the steered-end are lowered (or raised) when the rail gear switch is operated.
Control	To carry out the authorised duties of a machine or crane controller.
Controller of site safety	Person for ensuring a safe system of work on the railway.
Crane controller	A machine controller with other skills who has overall responsibility for the safe operations when on-track plant is carrying out mechanical lifting operations.
Down	In the direction away from London (generally).
Electrical control room	The control centre for electric traction current within a geographic area.*
Emergency stop button	Push button for stopping machinery in the event of an emergency.
Engineering supervisor	The person nominated to manage the safe execution of works within a worksite that has been set up on the railway.
Fixed-end	The end of a Basket 14 RRV with the unsteered road axle.
Four aspect colour light	Railway signal which uses four coloured lights to indicate whether the driver has to stop, needs to be prepared to stop or can proceed without restriction.
Gear selector	The control lever in the cab of a TD-18 RRV that is used to select the desired forward or reverse drive gear.
Grandfather rights	An arrangement by which a non-conforming process or situation is allowed to continue because it existed prior to new legislation (or instructions) being brought into force.*



Ground control panel	The control panel on a Basket 14 RRV that is located on its rotating superstructure and is accessed from ground level.
High ride	A type of RRV that is powered by its rubber tyres driving onto idler rail wheels.
Holding end	The end of a high ride RRV that should provide the braking so that the rail gear at the other end can be safely lowered (or raised).
Improvement Notice	An enforcement notice requiring remedial action because of a contravention of the provisions of the Health and Safety at Work etc Act 1974.
Integrated electronic control centre	A type of signal box that controls the points and signals for a whole route or large geographical area by electronic means.*
Knuckle-boom	A jointed hydraulically-powered arm used for lifting.
Locking pins	Steel pins on a Basket 14 RRV that are used to secure the rail gear in its fully lowered position.
Logic controller	A device that uses a sequence of programmable instructions to control external systems using its outputs, with the state of the device's inputs determining which outputs are set.
M&EE Networking Group	Industry working group concerned with the operation of plant on railways in Great Britain.
Machine and crane controller logbook	A book that is formally reviewed as part of the Sentinel competence management system in which machine and crane controllers record their experience of working with on-track plant.
Machine controller	A person trained and authorised to control and supervise an item of on-track plant other than a rail crane.*
Mobile elevating work platform	The generic name given for any wheeled machine designed to provide a safe working platform for one or more operatives and capable of adjusting this height under the control of the operator.*
National Competency Control Agency	The organisation responsible for managing the issue and control of qualifications to staff working in certain safety critical roles.
National Incident Report	A report following an incident that is circulated to the railway industry giving technical or operating advice.
Office of Rail Regulation	The independent health and safety regulator for the railway industry in Great Britain.
On/off-tracking	The process of placing an RRV on, or removing it from, the track.
On-track machine	Any piece of specialist railway plant which moves only on the rails and is normally self-propelled.*

On-track plant	Engineering plant with rail wheels including on-track machines and road-rail vehicles.*
Operator	The person competent to operate on-track plant.
Overbridge	A bridge that goes over the railway.
Overhead line equipment	An assembly of metal conductor wires, insulating devices and support structures used to bring an overhead electric traction current to trains.
Person in charge of possession	The person who manages safe access to the track for work to take place during a possession.
Possession	A section of one or more tracks that are blocked for a period of time to permit work to be safely carried out on or near the line.
Powered plant proficiency certificate	A certificate that some contractors issue to their staff to show they competent to operate powered plant. British Rail issued similar certificates before railway privatisation.
Rail gear	Sub-assembly on one end of an RRV comprising the rail wheels and the mechanical components used to lower and raise them.
Rail gear arms	Structural arms on the rail gear of a Basket 14 RRV that pivot on the chassis.
Rail gear lever	The control lever in the cab of a TD-18 RRV that is used to lower or raise the rail gear.
Rail gear selector switch	The switch in the cab of a TD-18 RRV that determines whether the rail gear at the front or the rear is lowered (or raised) when the rail gear lever is operated.
Rail gear switch	The toggle switch on a Basket 14 RRV that is used to lower (or raise) the rail gear.
Rail Plant Association	Industry association for organisations involved with the operation of rail plant.
Railway Group standard	A document issued by the RSSB mandating technical or operating standards.
Railway industry standard	A voluntary standard, issued by the RSSB, defining functional and technical requirements that industry parties have agreed to work to. It can be mandated by a railway organisation (eg Network Rail) as part of a company standard or as contract condition.
Railway Safety and Standards Board	Organisation responsible for railway standards and co-ordinating research relating to railway safety.
Retaining wall	A brick, concrete or masonry wall whose function is to hold back the side of an excavation or filled area.*
Road-rail access point	A designated place where an RRV can safely transfer from road to rail.

Road-rail vehicle	A vehicle that can travel under its own power on the road and also, by virtue of a rail guidance system, on railway track. Such vehicles are not allowed to operate outside possessions.
Rule Book	The publication detailing the responsibilities of staff engaged on the railway.*
Sentinel	The system used by Network Rail for managing the competence of staff working in certain safety critical roles.
Steered-end	The end of a Basket 14 RRV having the steered road axle.
Technical file	Set of technical documents justifying a vehicle's compliance with technical standards which the vehicle acceptance body assesses when considering issuing a certificate of engineering acceptance.
Tread	The part of a rail wheel that runs on top of the rail.
Up	In the direction towards London (generally).
Vehicle acceptance body	Body authorised by the RSSB to assess the compliance of vehicles with railway standards and issue certificates of engineering acceptance.
Wander-lead modification	The modification, comprising a plug-in pendant controller, which was made to Basket 14 RRVs in response to ORR's Improvement Notice.

## Appendix C - Key standards current at the time

### European standards

EN280	Mobile elevating work platforms - design calculations - stability criteria - construction-safety - examinations and tests
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### Railway Group standards

GE/RT8000	Rule Book
GM/RT1300	Engineering acceptance of road-rail plant

### Rail industry standards

RIS-1530-PLT	Engineering acceptance of road-rail vehicles and associated plant
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### Network Rail company standards

NR/L3/OPS/048/TMMIND	Train operations manual industry mandatory section
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