Rail Accident Investigation Branch

Rail Accident Report

Runaway of a road-rail vehicle at Belle Isle Junction
16 May 2021

Report 04/2022
May 2022

This investigation was carried out in accordance with:

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

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Preface

The purpose of a Rail Accident Investigation Branch (RAIB) investigation is to improve railway safety by preventing future railway accidents or by mitigating their consequences. It is not the purpose of such an investigation to establish blame or liability. Accordingly, it is inappropriate that RAIB reports should be used to assign fault or blame, or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

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Where RAIB has described a factor as being linked to cause and the term is unqualified, this means that RAIB has satisfied itself that the evidence supports both the presence of the factor and its direct relevance to the causation of the accident or incident that is being investigated. However, where RAIB is less confident about the existence of a factor, or its role in the causation of the accident or incident, RAIB will qualify its findings by use of words such as 'probable' or 'possible', as appropriate. Where there is more than one potential explanation RAIB may describe one factor as being 'more' or 'less' likely than the other.

In some cases factors are described as 'underlying'. Such factors are also relevant to the causation of the accident or incident but are associated with the underlying management arrangements or organisational issues (such as working culture). Where necessary, words such as 'probable' or 'possible' can also be used to qualify 'underlying factor'.

Use of the word 'probable' means that, although it is considered highly likely that the factor applied, some small element of uncertainty remains. Use of the word 'possible' means that, although there is some evidence that supports this factor, there remains a more significant degree of uncertainty.

An 'observation' is a safety issue discovered as part of the investigation that is not considered to be causal or underlying to the accident or incident being investigated, but does deserve scrutiny because of a perceived potential for safety learning.

The above terms are intended to assist readers' interpretation of the report, and to provide suitable explanations where uncertainty remains. The report should therefore be interpreted as the view of RAIB, expressed with the sole purpose of improving railway safety.

Any information about casualties is based on figures provided to RAIB from various sources. Considerations of personal privacy may mean that not all of the actual effects of the event are recorded in the report. RAIB recognises that sudden unexpected events can have both short- and long-term consequences for the physical and/or mental health of people who were involved, both directly and indirectly, in what happened.

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

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Runaway of a road-rail vehicle at Belle Isle Junction, 16 May 2021

Contents

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Summary

At around 03:30 hrs on Sunday 16 May 2021, a road-rail vehicle ran away while being on-tracked at a road-rail access point near Belle Isle Junction in north London. The RRV ran downhill for approximately 600 metres before coming to a stop in a tunnel. Although no one was injured, the operator jumped from the road-rail vehicle before it entered the tunnel.

The road-rail vehicle ran away because it entered service with ineffective rail-wheel brakes and staff working with it were unable to stop the runaway. The brakes were ineffective because a valve in the braking system had been left open following maintenance. The possibility of this had not been recognised during the design or risk assessment of the brake system, and the situation had not been identified during operation or regular in-service testing.

Two underlying factors were identified. These were that the risk assessment undertaken in support of a modification to the machine to fit a direct rail wheel braking system was incomplete, and that the company responsible possibly did not have a thorough understanding of the unmodified machine or its original conversion for rail use.

RAIB has made two recommendations. One is addressed to the company which designed and fitted the direct rail wheel braking system, to revise its process for risk assessment, and the second to the owner of the machine, to review its strategy for confirming the ongoing integrity of the direct rail wheel brake system.

Additionally, two learning points have been identified. These reinforce the importance of organisations which design and implement changes to on-track plant sourcing the original design information to inform their decisions, and of those supplying and operating road-rail vehicles ensuring that suitable facilities are available for in-service testing.

Introduction

Definitions

1 Metric units are used in this report, except when it is normal railway practice to give speeds and locations in imperial units. Where appropriate the equivalent metric value is also given.

2 The report contains abbreviations which are explained in appendix A. Sources of evidence used in the investigation are listed in appendix B.

The incident

Summary of the incident

3 At about 03:30 hrs on Sunday 16 May 2021, a road-rail vehicle (RRV) ran away as it was being on-tracked at a road-rail access point (RRAP) between Belle Isle Junction and St Pancras station (figure 1). The RRV involved was of a type known as a Mobile Elevating Work Platform (MEWP). It ran downhill for approximately 600 metres into a tunnel before coming to a stop. No one was on the track along the route taken by the MEWP as it ran away, but the machine operator, who was in the MEWP's basket, jumped from it on realising that he could not stop the machine.

4 There was no damage to the infrastructure or the MEWP, and nobody was injured during the incident. The incident took place at a time when the area was under possession[1] for maintenance activities. As a result, there were no train services in the vicinity.

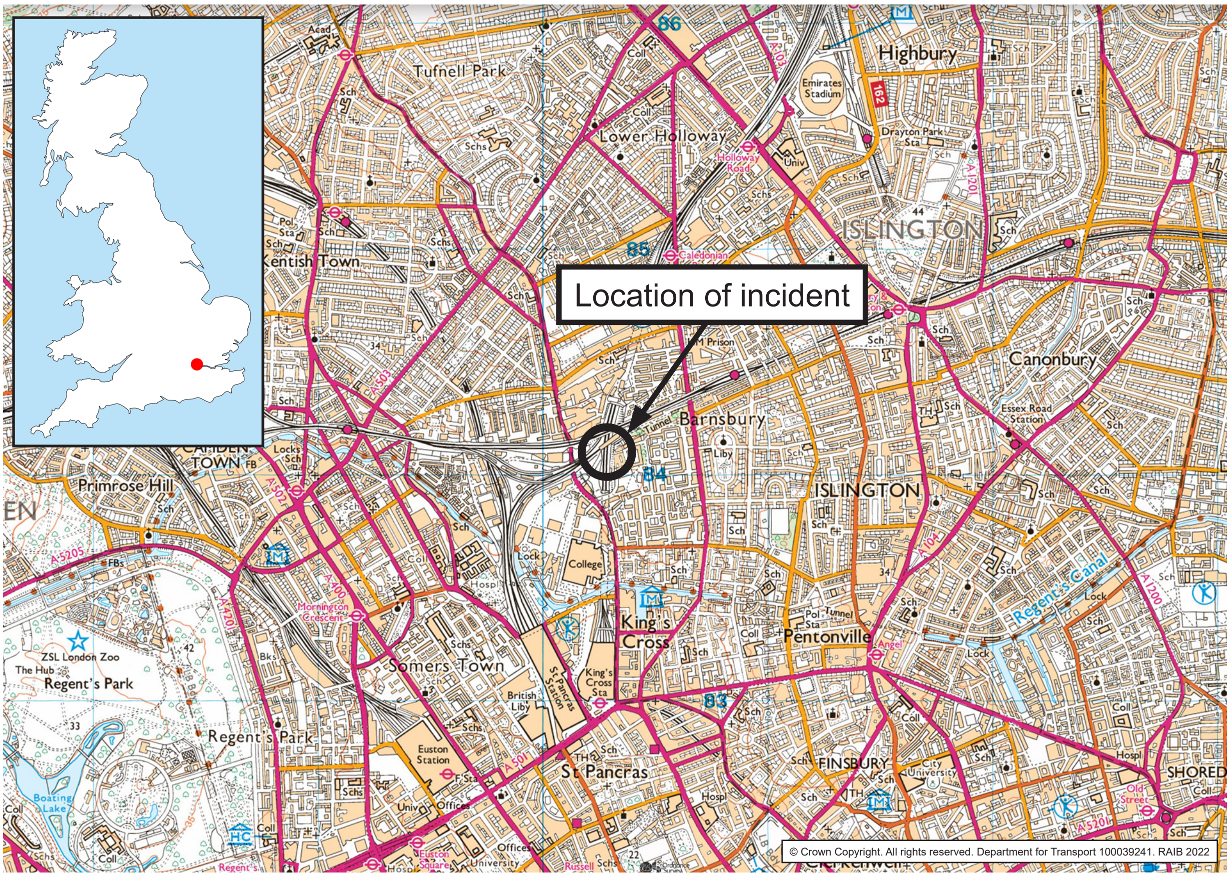

Figure 1: Extract from Ordnance Survey map showing location of incident

[1] A possession is a period of time during which one or more lines are blocked to trains to allow engineering work to be safely undertaken.

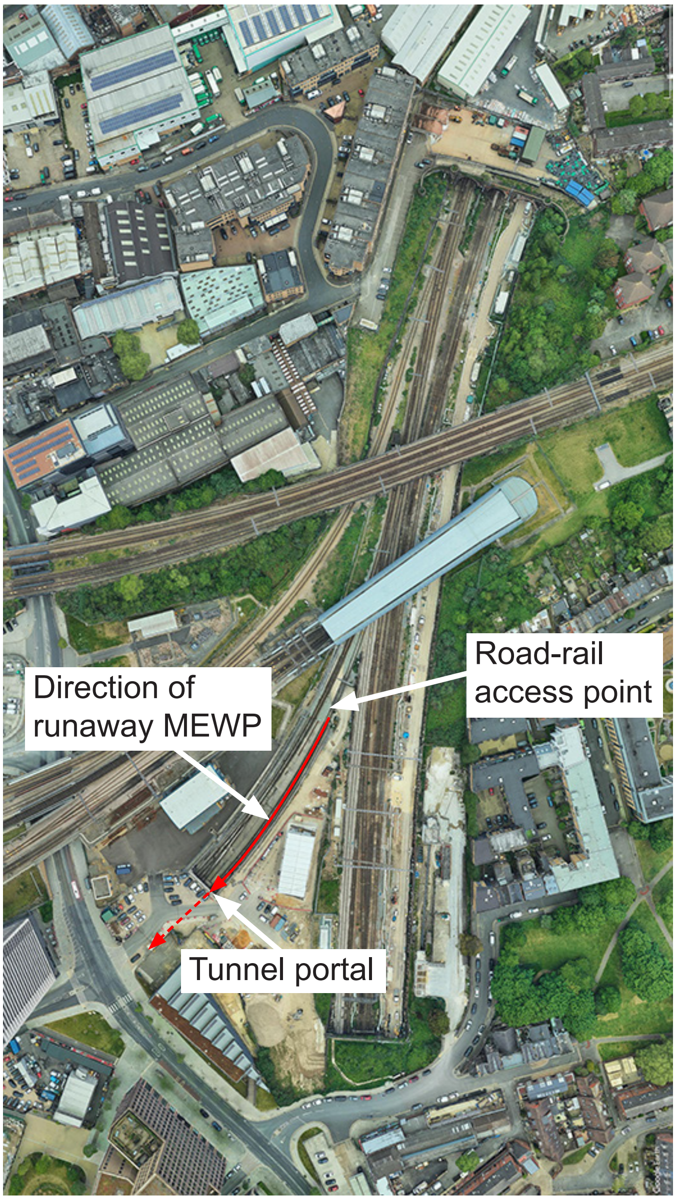

Figure 2: Overview of RRAP showing geographical relationship of key features and the path taken by the MEWP

Context

Location

5 The RRAP that was being used provides access to the up Canal Tunnel line, which links the East Coast main line at Belle Isle Junction, to Canal Tunnel Junction, north of St Pancras station. The RRAP is located approximately 100 metres north-east of the northern portal of Canal tunnel. A gradient sign at the RRAP indicates a slope of 1 in 28 downhill towards the tunnel.

6 The MEWP that ran away was the third of six being on-tracked at the RRAP that night. It had previously been stabled in a nearby compound.

Organisations involved

7 Network Rail owns and maintains the railway infrastructure where the incident occurred.

8 Morgan Sindall Infrastructure (referred to as Morgan Sindall in the rest of this report) was a principal contractor to Network Rail for the King's Cross remodelling project,[2] on which the MEWP was being used.

9 Pod-Trak Ltd (referred to as Pod-Trak in the rest of this report), a subsidiary of Pod-Trak Group, owned, maintained and supplied the MEWP involved. It also employed the machine operator, the Plant Operations Scheme Representative (POS Rep)[3] and the maintenance fitter.

10 The MEWP was manufactured in Italy and supplied to the UK in 2013 by ProMax Access Ltd (referred to as ProMax in the rest of this report), the manufacturer's UK agent.

11 Allan J Hargreaves Plant Engineers Ltd (referred to as Hargreaves in the rest of this report) modified the MEWP with its own design of direct rail wheel braking system (DRWB) in 2014.

12 Network Rail, Morgan Sindall, Pod-Trak, ProMax and Hargreaves all freely co-operated with the investigation.

Rail equipment involved

13 The MEWP was a Platform Basket RR14 Evo (figure 3) weighing 12.8 tonnes. It is known as a type 9b[4] 'high-ride' RRV. In rail mode, the rail wheels of this type of high-ride RRV are lowered onto the rails and driven and braked by friction forces transmitted through the tyres of the road wheels onto stubs fitted at the ends of each rail axle (figure 4a). During road use these axles are raised out of contact with the road wheels (figure 4b). When being configured for use on rail, the rail wheels are hydraulically lowered onto the track. When the rail wheels come into contact with the rail, they lift the MEWP, and this movement continues until the rail wheel stubs are pressed firmly against the road wheel tyres.

14 Since 2014, this type of RRV has been fitted with brakes acting directly on its rail wheels. This is known as a direct rail wheel braking (DRWB) system (see paragraph 34). A DRWB system was retrofitted to all type 9b machines following previous runaway incidents. Network Rail led and financed this project between 2011 and 2014. The large number of machines to be converted led Network Rail to place contracts with several companies for the design and installation of DRWB systems. Hargreaves was one of the companies selected, and designed a DRWB system that was fitted to many RRVs, including the MEWP involved in this incident.

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[2] A major project to upgrade the East Coast main line including renewal of track, signalling and overhead line equipment at King's Cross.

[3] The role of POS Rep is described in Network Rail standard NR/L2/RMVP/0200/module P521, issue 3. The POS Rep was responsible for the safe delivery of all plant operations involving the MEWP.

[4] Classification of Road-Rail Vehicles is described in Rail Industry Standard RIS-1530-PLT (Rail Industry Standard for Technical Requirements for On-Track Plant and Their Associated Equipment and Trolleys), currently at issue 6.

Figure 3: The MEWP involved on the RRAP near Belle Isle Junction (after recovery)

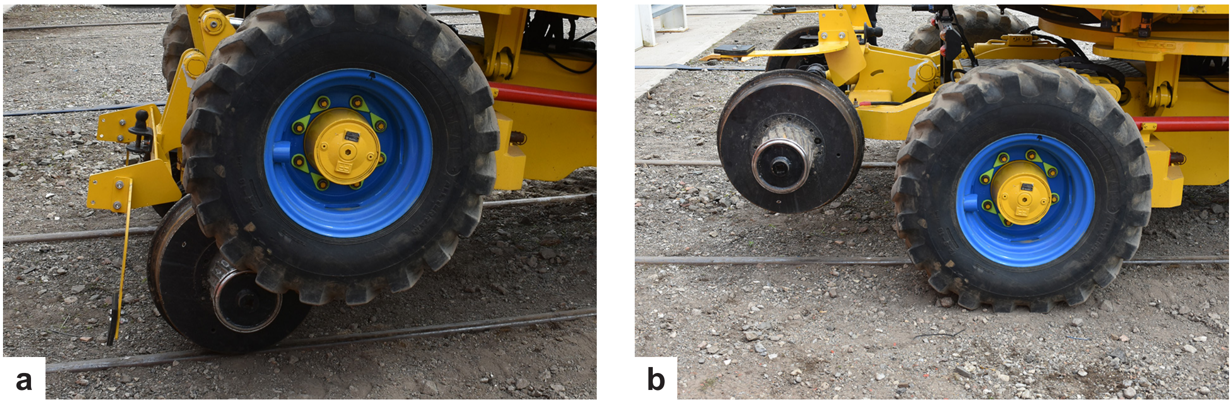

Figure 4: MEWP rail axle configurations in (a) rail configuration and (b) road configuration

15 One of the criteria for the modification was to retain the unmodified MEWP's machine operator's controls, which are located in the MEWP's basket. Machine operators use a joystick to drive the MEWP. Braking, both through the road and rail wheels, is applied when the MEWP is not specifically commanded to move (that is to say, when the joystick is released by the operator).

16 Only one axle on the MEWP can be steered, and this is referred to as the 'steering end', with the other referred to as the 'fixed end'. The MEWP is fitted with interlocks so that the rail axle on the steering end cannot be lowered until the rail axle on the fixed end is fully deployed, with its road-wheel tyres in firm contact with the rail-wheel stubs. This is another precaution to reduce the risk of a runaway when on- or off-tracking.

17 Pod-Trak requires that the MEWP is inspected in accordance with both statutory requirements and those of the machine manufacturer and supplier (see paragraph 46).

Staff involved

18 The machine operator had been working on the railway for around six years, with the last three years for Pod-Trak. He was trained and certified as a machine operator for MEWPs shortly after joining Pod-Trak. At the time of the incident, he had been working on the project at King's Cross for between two and three months.

19 The machine controller[5] was employed by an agency and had worked on the railway, in various roles, since December 2015. He had held the competence of machine controller for over three years.

20 The POS Rep had worked in various roles on the railway since April 2016 and at the time of the incident was working for Pod-Trak full time, after previously working for them through an agency. He was trained and authorised to work as a POS Rep for Pod-Trak in 2019.

21 The Pod-Trak fitter who last maintained the MEWP's braking system was a permanent Pod-Trak employee, having worked for them for around two years. He had worked on various types of agricultural machines, civil engineering plant and rail plant for over 20 years and held the necessary competencies to maintain the MEWP involved in the incident (see paragraph 69). Although on the site when the incident occurred, the fitter was not in the immediate vicinity of the MEWP or directly involved in the incident.

External circumstances

22 It was a mild night and dark at the time of the runaway. The approach road from where the MEWP had been stabled was covered in wet mud, due to the recent wet weather. This had coated the road tyres of the MEWP as it was driven to the RRAP. No other external factors contributed to the incident.

[5] The competent person who controls and supervises the safe operation of on-track plant that is being driven, or operated, by a machine operator.

The sequence of events

Events preceding the incident

23 On 2 March 2021, the MEWP underwent its last braking system maintenance before the incident. This included measurement of the brake pad to disc clearances (see paragraph 39) and a three-monthly torque test (see paragraph 51). This was done at Pod-Trak's facilities at Irlam, Manchester. On completion of the activities, a monthly dynamic brake test was carried out (see paragraph 50). No issues were identified during the test, and the MEWP went back into service. It was deployed over 30 times at eight locations, totalling over 250 hours of operational use, between the post-maintenance test and the runaway of 16 May 2021.

24 During this period, one further monthly brake check was undertaken, on 8 April 2021. No issues were identified during this test. A second monthly brake check due in early May 2021 was not carried out (see paragraph 90).

25 Pod-Trak informed RAIB that between 2 March 2021 and the incident the steepest gradient in worksites that the MEWP was used on was 1 in 99.

Events during the incident

26 At 02:48 hrs on 16 May 2021, the staff involved in the incident were granted access to the track which was under possession. Under the direction of the POS Rep and their respective machine controllers, the first two MEWPs were on-tracked successfully and moved north away from the RRAP to allow the incident MEWP also to be on-tracked. As with the preceding two MEWPs, the incident MEWP was driven down the access road where its tyres became coated in wet mud. The machine operator drove it onto the RRAP with the fixed end furthest from the tunnel. He then lined up the fixed end with the rails at the RRAP and deployed the rail wheels at that end. With those rail wheels fully deployed, and in firm contact with the road wheel tyres, the operator began to deploy the rail wheels on the steering end of the MEWP.

27 While the rail axle at the steering end was being lowered, the MEWP began rolling towards the tunnel. The machine operator tried to stop the MEWP by pressing the emergency stop plunger on the console in the basket, stopping the engine. When this did not work, he reset the plunger and restarted the engine in an attempt to regain control of the MEWP. The POS Rep, who was nearby, reported trying to stop the machine using the emergency stop plunger on the side of the machine's turret. Again, this would have only stopped the engine. However, the recorded data from the MEWP shows that he was unsuccessful in pressing the plunger, and the engine continued to run.

28 The MEWP knocked down a worksite marker board at the southern end of the worksite and a possession limit board beyond that, setting off railway detonators placed on the head of the rails to protect the southern limit of the possession. However, the line in the tunnel was closed to traffic because of another possession nearer to St Pancras station.

29 The speed of the MEWP increased and the machine operator, mindful of the presence of live overhead wires further along the route, jumped from the basket. The MEWP continued into the tunnel until it came to rest out of view. It is possible that the MEWP travelled further than its final resting position, as it could have been slowed by the uphill gradient after the low point in the tunnel and rolled back to where it was found.

Events following the incident

30 The incident was reported to a signaller at Three Bridges Rail Operating Centre at 03:35 hrs. Staff subsequently entered the tunnel and located the MEWP, which was stationary and with its engine still running. Photographs taken in the tunnel show that the rail axle at the fixed end was fully deployed, but the rail axle at the steering end was only partially deployed. The rail wheels at the steering end were in firm contact with the railhead and supporting the weight of the MEWP, but the road wheel tyres at this end were not in contact with the rail-axle stubs (figure 5).

Figure 5: The position of the rail axles when the MEWP came to rest (images courtesy of Network Rail)

31 The MEWP was recovered from the tunnel and subsequently quarantined nearby, before being taken for post-incident examination and testing (see paragraphs 43 to 45).

Background information

Certification of the MEWP

32 Network Rail requires that road-rail vehicles used on its infrastructure comply with Rail Industry Standard (RIS) RIS-1530-PLT. The MEWP, modified to include the DRWB system, was certified as complying with issue 4 of RIS-1530-PLT in 2014 and was further upgraded and recertified in 2020 to comply with the requirements of issue 6 of the standard. No modifications were made to the braking system as a result of this later upgrade. This certification remains valid for use of the MEWP on Network Rail infrastructure until 2027, after which the MEWP will need to be reassessed against the then current issue of standard RIS-1530-PLT.

33 The MEWP was certified for use on gradients of up to 1 in 25, in accordance with both issues 4 and 6 of Rail Industry Standard RIS-1530-PLT.

Operation of the DRWB system

34 The DRWB system is intended to be fail-safe. Braking is achieved by callipers pushing pads onto each side of discs that are mounted on the rail axles. The brake force is provided by springs holding the brake pads against the disc. When the MEWP is commanded to move, pressurised hydraulic fluid is admitted to the brake callipers which acts against the spring, releasing the brake. This ensures braking even when there is no hydraulic pressure. In service, the hydraulic pressure is applied by opening an electrically operated valve referred to as the 'park brake valve'.

35 The rail-wheel brakes are configured to be either on or off and machine operators cannot regulate the brake pressure to vary the braking force. However, the system includes hydraulic accumulators (which store pressurised hydraulic fluid) and reducing orifices. These soften the application of the direct spring brake, by reducing the flow rate of hydraulic fluid from the calliper.

36 The MEWP's hydraulic system is configured to normally supply pressurised fluid for the operation of the MEWP's basket and boom. However, when the machine operator commands the MEWP to either drive, to be steered or for the rail wheels to be raised/lowered, the relevant circuits for these commands are pressurised. When the MEWP is commanded to drive, the DRWB callipers are also pressurised, and the brakes are released allowing the road wheels to drive the rail wheels via the rail-axle stubs.

37 The MEWP is driven by a hydrostatic[6] drive, which also provides retardation through its road wheels, when it is not commanded to move. Movement and direction are selected via a joystick control in the machine operator's basket. To stop the MEWP, the machine operator releases the joystick and the drag generated by the hydrostatic system retards the road wheels, slowing the machine to a stop. In rail mode, the road tyres are in firm contact with the rail-axle stubs. This means that braking of the road wheels will therefore also brake the rail wheels. The DRWB system acts independently of this braking mechanism and is the only source of braking when the road wheels are not touching the ground or in firm contact with the rail-axle stubs, for example during on-tracking. The DRWB system should ensure effective braking in rail mode, even if the effectiveness of the hydrostatic road wheel braking system is compromised.

38 Machine operators cannot choose to use either DRWB or road-wheel braking; both brakes are active whenever the machine is not commanded to move. Machine operators have no indication what proportion of the braking effort is being provided by each system, nor any indication of whether each system is working correctly.

Maintenance of the DRWB system

39 Over time, the DRWB brake pads wear down and the spring clamping force, and consequent braking force, is reduced. To compensate for wear, the calliper needs to be manually adjusted. The procedure for checking the brake pad to disc clearance is defined in maintenance instruction AJH077, produced by Hargreaves. This specifies a three-month periodicity for the check and describes what to do if adjustment is necessary.

40 To establish the level of wear and the necessary adjustment, the gap between the disc and each pad needs to be known. Because access to the outboard brake pad is restricted, Hargreaves devised a process for manually releasing the brake so that the calliper can be moved by hand, making the total pad gap visible on the inboard side (figure 6). The total gap can then be measured to determine whether adjustment is required. To manually release the brake, the fitter needs to open the park brake valve and two other valves in the MEWP's hydraulic system, to pressurise the brake callipers. Manual operation of these valves has the same effect as the machine operator commanding the MEWP to drive, steer or raise/lower the rail axles, in that it causes the brake callipers to release.

41 The park brake valve is located under the machine's engine cover (figure 7). To manually open the valve, a knurled knob is rotated through a quarter turn by hand. In 2014 a barrel nut was added to cover the knob as a precaution against inadvertent manual operation of the valve. With the barrel nut fitted the position of the knob, and therefore the state of the valve, is not visually apparent. The valve is provided purely for maintenance purposes and should only be used by trained fitters; machine operators do not need to interact with it.

[6] Hydrostatic drive systems use oil pressure from a hydraulic pump to power hydraulic motors which, in this case, drives the road wheels. Because the system is closed, when the pump is commanded to stop driving the wheels the rotation of the wheels is resisted and the wheels are braked to a stop.

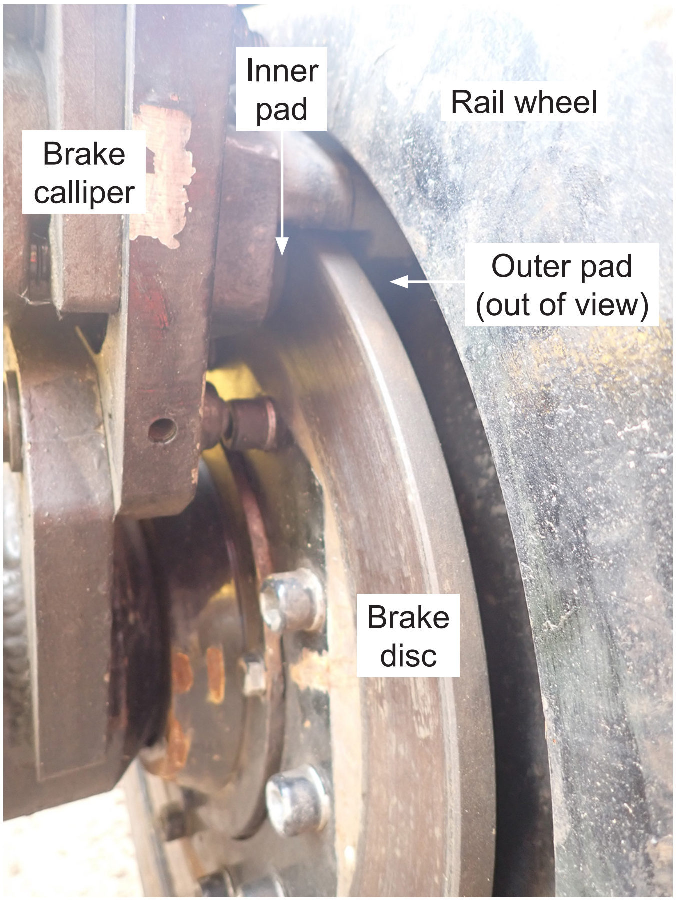

Figure 6: DRWB calliper and disc arrangement

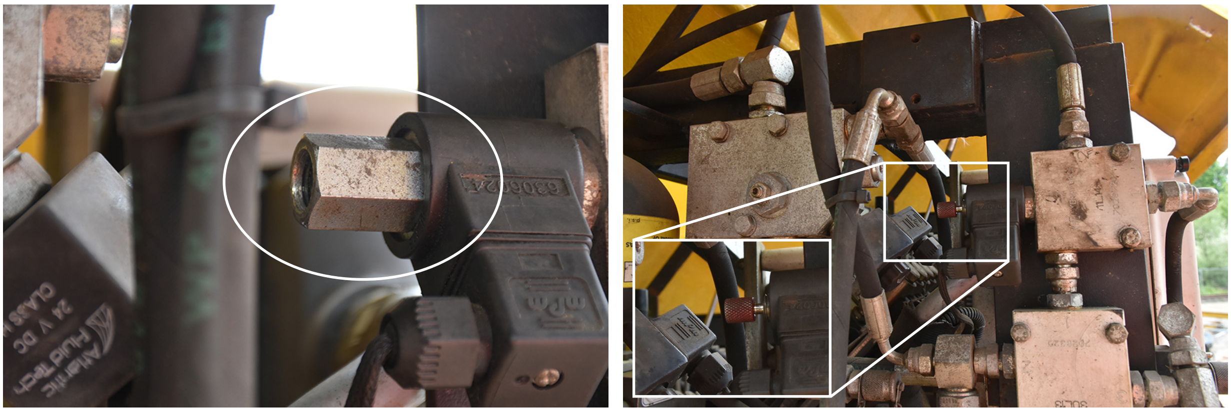

Figure 7: the park brake valve with barrel nut fitted (left) and removed, exposing the knurled knob (right)

42 If the park brake valve is open, the rail wheel brakes will be held off whenever the MEWP's hydraulic system is pressurised, and not just when movement is demanded. During on-tracking the operator is continually commanding the machine to either move, steer or lower the rail axles. This means that an open park brake valve will cause the brake callipers to be pressurised, and the rail-wheel brakes to be held off, when any of these activities are commanded. The hydraulic accumulator arrangement means that the callipers will remain pressurised, and the brakes held off, even after the circuit is no longer commanded to be pressurised, until the pressure in the accumulator decays sufficiently for the springs to re-apply the brakes.

Post-incident testing and examination

43 An examination of the MEWP after the incident showed that the park brake valve had been left open. Testing confirmed that, with the valve in that position, whenever the MEWP was commanded to move, steer or actuate the rail axles, pressurised hydraulic fluid was admitted to the brake callipers and the rail-wheel brake callipers were held off. If the MEWP was left idle, the brakes would remain held off until the hydraulic pressure decayed sufficiently from the accumulators (paragraph 35) to allow the springs to reapply the brakes.

44 During the testing, the park brake valve was closed and returned to the normal service position. The MEWP then complied with the braking requirements of RIS-1530-PLT issue 6. The brake disc to pad clearances were found to be well within limits and no other defects or issues were found.

45 To understand the braking effort that the road wheels were capable of providing, the park brake valve was manually reopened and the MEWP placed on a tilting platform. The angle of the platform was progressively increased, and the MEWP was found to hold in this static condition on a gradient of 1 in 25. This test demonstrated that with both rail axles deployed and dry, clean rail-wheel stubs and road tyres, the hydrostatic road-wheel braking system alone provided sufficient braking force to meet the requirements of RIS-1530-PLT (paragraph 33), although this is not representative of the incident conditions.

Brake testing and inspection

46 The Rule Book[7] requires that before on-track plant (OTP) is used, machine operators '*must carry out all the tests as shown in the specific instructions for the OTP*'. Pod-Trak procedure OP36C requires machine controllers to ensure that a dynamic brake test is undertaken and documented as part of their pre-use checklist. The checklist does not describe the form that test should take, although undertaking a dynamic brake test correctly is part of the self-propelled MEWP training which Pod-Trak machine operators undergo in order to qualify in that role.

47 The manufacturer's manual for the MEWP describes a 'daily working check' which includes '*travelling at 5 mph* (8 km/h) *along the track, apply*[ing] *the brake by releasing the joy-stick to effect an emergency stop'*. This check requires that the MEWP should stop within 5 metres. The manual states that, when the MEWP is used in rail mode, this test is to be carried out on the track as soon as the machine is on-tracked and before any operational use.

48 Hargreaves procedure AJH077 also specifies a pre-use check of the MEWP's brake systems. The pre-use check requires that, after on-tracking, the machine operator should 'drive for a short distance and release the drive control lever which in turn operates the service brake…and ensure the rail-wheel brakes are now applied'. There is no definition of how the application of the rail wheel brakes are to be checked. Hargreaves explained that it expects this to be done by the operators, or machine controllers, visually checking that the pads are in firm contact with the disc and/or by wiggling the calliper.

[7] GERT8000-HB15 'Duties of the machine controller (MC) and on-track plant operator', issue 5, dated December 2018.

49 Although a copy of the Hargreaves procedure is carried in the document box on each machine, Pod-Trak does not require its operators to undertake a physical inspection of the calliper during dynamic brake tests as it considered that it was not clear from the description in AJH077 that this was the intent of the procedure.

50 Hargreaves procedure AJH077 specifies that the pre-use check should also be done on a monthly basis. Based on its understanding of AJH077, Pod-Trak procedure OP36N.72 also requires a monthly brake test in which the machine is to be driven a short distance and then braked to confirm the functionality of the brakes. Pod-Trak again requires only the dynamic element of the test to be undertaken and does not require its operators to undertake a physical inspection of the calliper.

51 The current issue of RIS-1530-PLT (issue 6) requires that the performance of DRWB systems is regularly assessed by means of a torque test. Torque tests require that each rail wheel is individually tested to ensure that the performance of each brake meets the manufacturer's defined threshold. Hargreaves procedure AJH077 requires a torque test to be undertaken at three-monthly intervals.

52 The torque test involves parking the MEWP with the rail wheels braked but not deployed, so they are not externally influenced by the road wheels or the ground. A torque wrench, via a torque multiplier,[8] is attached to a square drive spigot on each rail wheel. The MEWP passes the test if the defined torque can be applied without causing the rail wheels to turn. Comparing successive test results gives a good indication as to any reduction in brake performance over time.

[8] A mechanical device that uses gears to increase the applied torque through mechanical advantage.

Analysis

Identification of the immediate cause

53 The MEWP ran away on a gradient because neither the direct rail wheel nor the road wheel braking systems were able to prevent its movement.

54 The MEWP started to run away when the fixed end rail wheels had been fully deployed and the steering end rail wheels were partially deployed. In this condition braking effort is normally provided by both the DRWB and the hydrostatic road-wheel braking systems acting on the wheels on the fixed end.

55 The MEWP had been certified for use on gradients of up to 1 in 25 after installation of the DRWB (paragraph 33). Therefore, the DRWB should have been capable of holding the MEWP on the gradient at the RRAP (paragraph 5).

Identification of causal factors

56 The MEWP ran away due to a combination of the following causal factors:

a. The condition of the road wheels was such that the hydrostatic road-wheel braking system at the fixed end was unable to hold the MEWP on the gradient at the RRAP (paragraph 57)

b. The MEWP entered service with ineffective direct rail wheel brakes because a valve in the DRWB system had been left open following maintenance (paragraph 61)

c. The fact that the park brake valve had been left open had not been identified during operation or regular in-service testing (paragraph 82)

d. The staff working with the MEWP were unable to stop it after it started to run away (paragraph 94).

Each of these factors is now considered in turn.

The road wheel brakes

57 The condition of the road wheels was such that the hydrostatic road-wheel braking system at the fixed end was unable to hold the MEWP on the gradient at the RRAP.

58 RAIB observed that at the time of the incident the tyres on the MEWP were coated in wet mud from the access road leading to the RRAP (paragraph 22). Wet mud acts as a lubricant and reduces the friction between the rubber tyres and steel rail-axle stubs. Consequently, this will have reduced the braking force of the road tyres on the rail-axle stubs.

59 Additionally, the contact between the road wheel tyres and the rail-axle stubs had worn a distinct profile across the wheel tread (figure 8). Whilst this wear is difficult to measure, RAIB found that it was around the limit defined by ProMax in its operating and maintenance manual (PAMP011RC). This wear would have further reduced the brake force from the fixed end road wheel tyres. The steering end rail wheels were not engaged with the road tyres, and the road tyres were off the ground at the time of the runaway, as the operator was in the process of lowering them (paragraph 26).

Figure 8: Road tyre wear profile

60 The combined effect of the wet mud and wear reduced the brake force to such a degree that the road wheel brakes at the fixed end were unable to hold the MEWP on the gradient. However, with the rail wheels in contact with the rail, the DRWB should be sufficient to maintain the MEWP in a safe condition and any braking effort from the hydrostatic road-wheel braking system should not be necessary to prevent movement.

The park brake valve

61 The MEWP entered service with ineffective direct rail wheel brakes because a valve in the DRWB system had been left open following maintenance.

62 During maintenance to compensate for brake pad wear, fitters are required to manually open the park brake valve (paragraph 39). It is this valve that was found open following the incident (paragraph 43).

63 Although it cannot be totally discounted that the park brake valve position was changed at some time other than during a maintenance activity, RAIB considers this unlikely, given the valve's location and the absence of other situations requiring access to it.

64 This causal factor arose due to a combination of the following:

a. It is likely that during a routine maintenance activity to compensate for brake pad wear, a fitter left the park brake valve open (paragraph 65)

b. The DRWB design had not identified a need for additional safeguards to prevent the park brake valve being left open. This is a probable factor (paragraph 71)

c. The MEWP was returned to service with the park brake valve left open when it should have been closed (paragraph 79).

Each of these factors is now considered in turn.

Position of the park brake valve

65 It is likely that during a routine maintenance activity to compensate for brake pad wear, a fitter left the park brake valve open.

66 The last known occasion requiring access to, and the manual opening of, the park brake valve, prior to the incident at Belle Isle, was on 2 March 2021. This was during a three-monthly maintenance check which required the brake pad to disc clearances to be measured and adjusted, if required (paragraph 40). This check was carried out by a fitter at Pod-Trak's Irlam facility, in accordance with Pod-Trak procedure OP36N.72, which provides a link to further detail in Hargreaves procedure AJH077.

67 Hargreaves procedure AJH077 provides step-by-step instructions for carrying out the task and for bringing the MEWP back into service. On completion of the adjustment, it requires fitters to close the park brake valve and then check that they have done so by attempting to turn a rail wheel by hand. This is done with the MEWP's hydraulic system pressurised (by leaving two other valves open). If carried out in the correct order, this would reveal whether the park brake valve has been left open because a fitter would find that they could turn the wheel when it should be braked.

68 For the park brake valve to be open and for this to remain undetected, the fitter would have to have missed out two steps in the procedure, both the closing of the valve and the subsequent attempt to rotate the wheel. RAIB has been unable to determine why both steps were omitted on 2 March, but the fitter explained that he always refers to the relevant maintenance instruction for the task and does not rely on his personal recollection of how to perform the activity. This is because, despite this check being a relatively frequent activity, there are several variants of the brake system fitted to different generations and types of machine.

69 Pod-Trak requires the competence of its fitters to be assessed against 11 relevant Rail Plant Association assessment modules on a two-year cycle (Rail plant maintenance and repair competency assessment 2016, issue 3). The fitter understood the procedure that should be followed when checking the brake pad clearances on the MEWP and had been assessed as competent in the two years prior to the incident.

70 RAIB has been unable to identify any specific reason for the fitter missing out the two steps in Hargreaves procedure AJH077, nor has it found that such omissions were a regular occurrence at Pod-Trak. RAIB attempted to understand whether factors such as fatigue, the work environment, distraction or interruption were present. However, the long time between the last known occasion when the park brake valve was manually opened (2 March 2021) and the runaway meant it was not possible to draw any firm conclusions about these possible influences.

Arrangements in place to prevent the valve being left open

71 The DRWB design had not identified a need for additional safeguards to prevent the park brake valve being left open. This is a probable factor.

72 The lack of an engineering, or other, safeguard to prevent the park brake valve being left open after the maintenance intervention was probably because the risk of the valve being left open had not been identified and addressed during either the design process, the approval of the machine for use, or as a result of in-service feedback.

73 Hargreaves assessed the risks from the DRWB modification using a Failure Modes and Effect Analysis. Although this had identified the hazard of the park brake valve being stuck open in use, it did not consider the possibility that it could be left in the open position after being operated manually. This was possibly because Hargreaves did not undertake any operability study[9] of the design or maintenance instructions (see paragraph 95).

74 Additionally, the mitigation proposed for the identified hazard was that the pre-use checks (paragraph 46) would reveal the loss of DRWB effort because of the stuck-open valve. However, this is unlikely to have been reliable in identifying this fault condition as explained in paragraph 87. Also, the daily working check (paragraph 45) would be unable to differentiate between brake effort from the road-wheel braking and the DRWB, thereby also hiding any occurrences of this fault (paragraph 86).

75 Network Rail standard NR/L2/RMVP/0200/P300 'Infrastructure Plant Manual: Plant Approval and Design', issue 4, requires that any RRV to be used on Network Rail infrastructure is subject to the plant approval process described in RIS-1710-PLT 'Engineering certification of railborne plant and the assessment of non-railborne plant', issue 2.1. This includes a check of a machine's compliance with applicable standards. For RRVs, the primary relevant standard is RIS-1530-PLT, and the MEWP was certified against the latest issue of this standard (paragraph 32).

[9] A structured and systematic examination of a process or operation in order to identify and evaluate risks that may arise from its use.

76 Network Rail also applies a product acceptance process (NR/L2/RSE/100/05 - 'Network Rail Assurance Panel Processes: Product acceptance and change to Network Rail operational infrastructure') to equipment and materials to be used on its infrastructure. The objective of this process is to assess the compatibility of those products with the infrastructure and to understand the potential for importing risk to the railway. The product acceptance process has included RRVs in its scope since 2004. Network Rail has stated that completion of the plant approvals process, with the issuing of an Engineering Acceptance Certificate or an Engineering Conformance Certificate[10] with suitable operational limitations, has historically been taken as sufficient evidence for meeting the requirements of product acceptance.

77 On 8 May 2016, a MEWP ran away at Brentwood station in Essex (see paragraph 108). Although this incident involved a different type of MEWP, it was fitted with the same Hargreaves DRWB system. A rail industry investigation found that it also happened because the park brake valve had been left open. Network Rail undertook a technical review of the incident which, with the assistance of Hargreaves, was completed in August 2016.

78 The technical review identified the lack of an engineered safeguard and proposed alternative engineering solutions to mitigate against recurrence. Network Rail reported that the technical review was shared internally for it to consider the options, but none of the solutions were implemented before this incident. Network Rail was unable to provide any evidence as to why none of the proposals were adopted. Hargreaves reported that this incident was the reason for the introduction of the three-monthly torque tests in 2017. However, this mitigation was not effective in identifying this failure mode (see paragraph 91), probably as a result of Hargreaves' incomplete understanding of the engineering of the unmodified machine (paragraph 100). In addition to the torque test, Pod-Trak continued to rely on the daily working check as a mitigation for hazards related to the park brake valve.

Returning machines into service after maintenance

79 The MEWP was returned to service with the park brake valve left open when it should have been closed.

80 Pod-Trak reported that it does not require any additional checks on machines or recommissioning tests after maintenance, but relies on adherence to the maintenance procedures provided by Hargreaves (AJH077) and ProMax (PAMP011RC).

81 On return to service the machines become subject to the normal testing and inspection regimes (paragraphs 46 to 52). However, these were ineffective at detecting that the park brake valve had been left open.

[10] Until 2015, compliance with the relevant technical standard GM/RT1300 was documented by issuing an engineering acceptance certificate (EAC). With the introduction of RIS-1530-PLT issue 6 in 2015, EACs were superseded by engineering conformance certificates (ECCs).

Brake testing and inspection

82 The fact that the park brake valve had been left open had not been identified during operation or regular in-service testing.

83 This causal factor arose because:

a. Brake testing undertaken prior to use did not identify that the park brake valve had been left open (paragraph 84)

b. The monthly brake tests did not identify that the park brake valve had been left open (paragraph 88)

c. The three-monthly brake torque tests did not identify that the park brake valve had been left open (paragraph 91).

Each of these factors is now considered in turn.

Pre-use dynamic brake test

84 Brake testing undertaken prior to use did not identify that the park brake valve had been left open.

85 The on-tracking process was not completed before the MEWP ran away and, therefore, no brake testing (paragraphs 46 to 52) was carried out. However, the MEWP had been used on over 30 occasions at eight sites since 2 March 2021, when the park brake valve was believed to have been last manually opened. Pod-Trak confirmed that there were no reports of poor brake performance in that period. However, Pod-Trak stated that the MEWP had not been used on any significant gradients during that period (paragraph 25).

86 As explained in paragraph 47, operators undertake the daily working check described in the MEWP manual. RAIB considers that the ineffective DRWB brake system had not been identified before the incident probably because the machine had only been used on moderate gradients and in less onerous (not muddy or wet) conditions, allowing the hydrostatic road-wheel braking system to provide sufficient retardation/holding force. The daily working check does not provide any intelligence about the state of the individual brake systems, only the overall level of braking achieved (paragraph 38).

87 RAIB recognises that Hargreaves procedure AJH077 specifies a pre-use check (paragraph 46) which includes the requirement to 'ensure that the rail-wheel brakes are now applied'. Hargreaves expects this to be carried out by machine operators or controllers on site after the machine has been driven a short distance on the track. It requires them to confirm that the brake pad-disc gap, which may be as little as between 0.25 and 0.5 mm, has closed, or to wiggle the brake calliper to infer that the pads are in firm contact with the disc. The execution of this approach on site is considered unlikely to be reliable in identifying this fault condition. Furthermore, testing on the machine involved after the incident revealed that the hydraulic pressure will soon decay after the machine has stopped being driven, resulting in the direct rail wheel brakes beginning to apply, even when the parking brake has been left open.

Monthly brake tests

88 The monthly brake tests did not identify that the park brake valve had been left open.

89 As the monthly check is a repeat of the testing undertaken prior to use, it is unlikely to reveal the incorrect position of the park brake valve for the same reasons as discussed in paragraphs 84 to 87.

90 RAIB observes that the monthly brake test required in early May 2021 was not undertaken because the machine was stabled near to the operational railway, and the attending fitter did not have ready access to a section of rail on which to undertake the test. However, when the machine was next on-tracked the outstanding check was carried out immediately.

Torque testing

91 The three-monthly brake torque tests did not identify that the park brake valve had been left open.

92 The last three-monthly torque test (paragraph 47) of the MEWP was on 2 March 2021, when it met the requirement. The MEWP also met the requirement when tested after the incident with the park brake valve closed and operating normally (paragraph 44).

93 The torque test is intended to measure the performance of a DRWB. It can identify issues such as worn or contaminated brake pads, or maladjusted callipers. However, it is unlikely to identify the specific fault present in this incident, because the machine would almost certainly have been parked in road configuration with no requirement for the hydraulic system to have been pressurised during the test. In this condition, the full brake force provided by the springs in the calliper would be applied.

Staff unable to stop the machine

94 The staff working with the MEWP were unable to stop it after it started to run away.

95 The machine operator quickly tried to arrest the runaway by pushing the emergency stop plunger[11] in the basket, in the expectation that it would stop the MEWP. It did not do so; it only stopped the MEWP's engine. He managed to restart the engine, but still could not stop the MEWP, and jumped from the machine onto the track.

96 Switching off the engine (and consequently the hydraulic pump) by pressing the emergency stop plunger will have eventually restored braking from the DRWB system because, over time, the hydraulic pressure holding the disc brakes off would have decayed away and the springs would have re-applied the brakes. However, machine operators are unlikely to know this, and the length of time taken for the brakes to become fully effective is uncertain and will vary from machine to machine.

97 The machine operator stated that he had not received any specific training on how to deal with a runaway machine. The machine controller was not expected to interact with the machine in the event of a runaway, and his training reflected this.

[11] The emergency stop plunger on the machine stops the engine and consequently switches off the hydraulic system pump which is driven by it.

Identification of underlying factors

Risk assessment

98 The risk assessment undertaken by Hargreaves in support of its DRWB modification was incomplete. This is a possible underlying factor.

99 When it designed the DRWB system, Hargreaves' process for undertaking risk assessments did not require it to review the operability and maintainability of its design modification and associated instructions (paragraph 72). Had the process included such consideration, it is possible that Hargreaves would have formally identified the hazard of the fitter forgetting to close the park brake valve after the maintenance intervention to adjust the brake system for brake pad wear, and provided a more robust means of managing the risk.

Hargreaves' understanding of the design of the unmodified machine and the original conversion

100 Hargreaves did not have a thorough understanding of the design of the unmodified MEWP or its original conversion for rail use. This is a possible underlying factor.

101 The DRWB project was led and financed by Network Rail. RAIB's investigation into the runaway of a MEWP that occurred at Bradford Interchange in 2018 (see paragraph 109) found that the contract placed at the time between Network Rail and the companies undertaking the design and installation of the DRWB systems contained no provision for the companies to be provided with the proprietary information required to fully understand the RRVs that they were modifying.

102 This lack of information possibly explains why Hargreaves did not recognise that the torque test was unlikely to identify the fault of the park brake valve being inadvertently left open (paragraph 91).

Observations

Management of runaway risk

103 The safe system of work planned and implemented by Morgan Sindall did not consider the risk of runaway plant.

104 Module 5 of Network Rail standard NR/L2/OHS/019,[12] 'Management of runaway risk', requires that, where work is to be undertaken within five miles of where rail mounted plant is to be used on a gradient of 1 in 100 or steeper, the potential risk of a runaway should be recognised. It identifies a series of controls that should be considered for implementation to manage the associated risks. The controls include use of compliant plant, provision of barriers to the progression of the runaway and provision of warnings to those working on the line.

[12] The compliance date for NR/L2/OHS/019/05 Issue 1 was 6 March 2021. However, Network Rail experienced issues complying with the module in this timeframe and, in October 2021, applied for a temporary variation to delay the compliance date until March 2022.

105 While no track workers were put at risk in this incident, because none were working along the route taken by the MEWP, Morgan Sindall should have considered the associated risks of a runaway in order to meet the requirements of Module 5 of NR/L2/OHS/019. The front page of Safe Work Packs created by Morgan Sindall include a requirement for the planner to identify whether there is a high risk of a runaway. However, in this case this provision was recorded as 'not applicable', resulting in an additional section describing the control measures to be taken not being included in the pack. Morgan Sindall explained that this arose because the safe system of work planner had missed a briefing on module 5 of NR/L2/OHS/019 two weeks before the runaway and, therefore, was not aware of these requirements.

Previous occurrences of a similar character

106 RAIB has investigated several previous runaway incidents including:

- runaway of a road-rail vehicle at Glen Garry on 5 December 2007, RAIB report 05/2009
- road-rail vehicle runaway incidents at Brentwood, Essex on 4 November 2007, and at Birmingham Snow Hill on 31 October 2007, RAIB report 11/2009
- runaway and collision of a road-rail vehicle near Raigmore, Inverness on 20 July 2010, RAIB report 10/2011
- collision of a road-rail vehicle with a buffer stop at Bradford Interchange station on 25 March 2012, RAIB report 09/2013
- runaway of a road-rail vehicle and the resulting collision in Queen Street High Level Tunnel, Glasgow on 21 April 2013, RAIB report 15/2014

107 RAIB conducted a class investigation into runaways of RRVs and their trailers (RAIB report 27/2009). All of these investigations were undertaken on incidents that occurred before the use of DRWBs was mandated and the recommendations made in the reports have helped shape the management of the risks of RRV runaways.

108 Of particular relevance to this incident are runaways that occurred at Brentwood station in Essex on 8 May 2016 and Bradford Interchange on 8 June 2018. The MEWP that ran away at Brentwood was a Genie Z60 type of machine, fitted with a similar DRWB modification designed and implemented by Hargreaves. This incident was investigated by Network Rail and the investigation revealed that it was also caused by the park brake valve being open in service (paragraph 77).

109 The same Genie Z60 MEWP also ran away at Bradford Interchange (RAIB report 01/2019). On this occasion RAIB's investigation found that this was because the DRWB system had not been correctly maintained. Fitters were not following the original equipment manufacturer's instruction, resulting in the brake callipers not being adjusted to compensate for brake pad wear.

Summary of conclusions

Immediate cause

110 The MEWP ran away on a gradient because neither the direct rail wheel nor the road wheel braking systems were able to prevent its movement (paragraph 53).

Causal factors

111 The causal factors were:

a. The condition of the road wheels was such that the hydrostatic road-wheel braking system at the fixed end was unable to hold the MEWP on the gradient at the RRAP (paragraph 57).

b. The MEWP entered service with ineffective direct rail wheel brakes because a valve in the brake system had been left open following maintenance (paragraph 61). This causal factor arose due to a combination of the following:

   i. It is likely that during a routine maintenance activity to compensate for brake pad wear, a fitter left the park brake valve open (paragraph 65, No recommendation)

   ii. The DRWB design had not identified a need for additional safeguards to prevent the park brake valve being left open. This is a probable factor (paragraph 71, **Recommendation 1**)

   iii. The MEWP was returned to service with the park brake valve open (paragraph 79, **Recommendation 2**).

c. The fact that the park brake valve had been left open had not been identified during operation or regular in-service testing (paragraph 82, **Recommendation 2**). This causal factor arose due to a combination of the following:

   i. Brake testing prior to use did not identify that the park brake valve had been left open (paragraph 84)

   ii. The monthly brake tests did not identify that the park brake valve had been left open (paragraph 88)

   iii. The three-monthly brake torque tests did not identify that the park brake valve had been left open (paragraph 91).

d. The staff working with the MEWP were unable to stop it after it started to run away (paragraph 94, **Recommendation 1** and **Learning point 1**, in so far as reducing the likelihood of the runaway is likely to be the primary means of mitigating this risk associated with this factor).

Underlying factors

112 The underlying factors were:

a. The risk assessment undertaken by Hargreaves in support of its DRWB modification was incomplete. This is a possible underlying factor (paragraph 98, **Recommendation 1**)

b. Hargreaves did not have a thorough understanding of the design of the unmodified MEWP or its original conversion for rail use. This is a possible underlying factor (paragraph 100, **Learning point 1**)

Observation

113 The safe system of work planned and implemented by Morgan Sindall did not consider the risk of runaway OTP because the member of staff that created it was unaware of the requirements of Module 5 of Network Rail standard NR/L2/OHS/019 'Management of runaway risk' (paragraphs 103 and 116).

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

114 In June 2021 Hargreaves issued a bulletin to owners of OTP with the Hargreaves DRWB system. This bulletin described an engineering solution intended to prevent machines entering service with their park brake valve left open. Hargreaves required that MEWPs fitted with its DRWB system be modified at the earliest available opportunity.

115 Hargreaves reported that it has been developing its approach to the risk assessment of its designs and modifications since the design of the DRWB system in early 2014, and believes that its risk assessment process is more rigorous than at the time of the design of the machine involved in the incident.

116 Since the incident, Morgan Sindall has ensured that all of its safe system of work planners who missed the briefing on Module 5 of NR/L2/OHS/019 have now been briefed. It has undertaken some sampling of Safe Work Packs to understand the level of compliance and to ensure that appropriate consideration has been given to the risk of runaway plant.

Recommendations and learning points

Recommendations

117 The following recommendations are made:[13]

1 *The intent of this recommendation is for Hargreaves to fully identify and appropriately mitigate the risks associated with its on-track plant designs.*

Hargreaves should continue to review and revise as necessary its process and associated guidance for assessing the risks from its designs of rail plant, so that it specifically requires consideration of errors that may occur during operation and maintenance. This should include a requirement to update and revise risk assessments based on operational feedback and the contents of, and any changes to, operating and maintenance procedures (paragraphs 111a a.ii, and c and a).

2 *The intent of this recommendation is for Pod-Trak to have a regime that provides it with a reliable understanding of the integrity of the direct rail wheel brake systems on its on-track plant, so that the machines only enter service with fully functional brakes.*

Pod-Trak should review its strategy for confirming the ongoing functional performance of the direct rail wheel brake systems on its on-track plant to confirm that it gives sufficient confidence in the integrity of the system throughout its time in service. This review should include consideration of the checks to be undertaken before vehicles are reintroduced into service following maintenance and inspection, the checks to be undertaken on an ongoing basis and any necessary pre-use checks. It should also identify and mitigate the risks associated with live testing. From the revised strategy Pod-Trak should issue updated procedures based on this strategy and brief them to relevant staff as part of their implementation (paragraph 111a a.ii, iii, and b).

Note: this recommendation may also apply to other plant operators.

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

Additionally, for the purposes of regulation 12(1) of the Railways (Accident Investigation and Reporting) Regulations 2005, these recommendations are addressed to the Office of Rail and Road (ORR) to enable it to carry out its duties under regulation 12(2) to:

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

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

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

Learning points

118 RAIB has identified the following important learning points:[14]

1. Organisations that design and implement changes to on-track plant are reminded of the importance of ensuring that original design information is sourced to allow for informed design decisions and accurate risk assessments (paragraph 112b).

2. Suppliers and operators of RRVs are reminded of the importance of ensuring that suitable facilities are available for undertaking regular in-service testing (paragraph 90).

[14] 'Learning points' are intended to disseminate safety learning that is not covered by a recommendation. They are included in a report when RAIB wishes to reinforce the importance of compliance with existing safety arrangements (where RAIB has not identified management issues that justify a recommendation) and the consequences of failing to do so. They also record good practice and actions already taken by industry bodies that may have a wider application.

Appendices

Appendix A - Glossary of abbreviations and acronyms

DRWB	Direct rail wheel brake
MEWP	Mobile elevating work platform
OTP	On-track plant
POS	Plant operations scheme
RIS	Rail industry standard
RRAP	Road-rail access point
RRV	Road-rail vehicle

Appendix B - Investigation details

RAIB used the following sources of evidence in this investigation:

- information provided by witnesses
- information taken from the RRV’s data recorder
- recorded telecommunications involving staff on site and signallers
- site photographs and measurements
- weather reports and observations at the site
- post-incident testing of the RRV involved
- documentation relating the DRWB project
- Engineering Acceptance Certificates and Engineering Conformance Certificates relating to the MEWP involved
- a review of material generated in response to a similar incident in 2016
- a review of previous RAIB investigations that had relevance to this incident.

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