RAIB

Rail Accident Investigation Branch

Rail Accident Report

Fatal accident at Waterloo Underground station, London
26 May 2020

Report 05/2021
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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.

RAIB's findings are based on its own evaluation of the evidence that was available at the time of the investigation and are intended to explain what happened, and why, in a fair and unbiased manner.

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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Fatal accident at Waterloo Underground station, London, 26 May 2020

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Summary

At about 10:10 hrs on 26 May 2020, at Waterloo Underground station in London, a passenger fell into the gap between the northbound Bakerloo line platform and the train from which he had just alighted. A large gap existed between the train and the platform because of the track curvature at the location of the passenger's fall. The passenger was unable to free himself and the train departed with the passenger still in the gap, crushing him as it moved off. He remained motionless on the track and was subsequently hit by a second train that entered the station.

The accident occurred when there were no staff or other members of public nearby to assist the fallen passenger. Train despatch on the Bakerloo line platforms at Waterloo was undertaken by the train operator (driver) using a closed-circuit television system to view the side of the train alongside the platform. With only his head and arm above platform level, the passenger was difficult to detect on the despatch monitors, and was not seen by the train operator. The operator of the following train was unaware of the passenger because their attention was focused on the platform and the train's stopping point, until after the train had struck the passenger.

The investigation found that London Underground's risk assessment processes did not enable the identification and detailed assessment of all factors that contributed to higher platform-train interface (PTI) risk at certain platforms. Consequently, although London Underground had implemented some location-specific mitigation measures at the PTI, it had not fully quantified the contribution of curved platforms to the overall PTI risk, and so was unable to fully assess the potential benefits of additional mitigation at these locations.

The investigation also found that the model used by London Underground to quantify system risk makes no allowance for non-fatal injuries, and so understates the risk of harm to passengers at the PTI and presents an incomplete picture of system risk, with the potential to affect London Underground's safety decision making.

RAIB has made three recommendations to London Underground. The first relates to the need to recognise and assess location-specific risks so they can be properly managed. The second deals with the need to ensure that safety management processes include the ongoing evaluation of existing safety measures at stations, and provide periodic risk assessment for individual locations at intervals which reflect the level of risk present. The third recommendation relates to the need for effective delivery of actions proposed by internal investigation recommendations.

Introduction

Definitions

1 Metric units are used in this report, in accordance with normal practice on London Underground Limited (LUL).

2 The report contains abbreviations and acronyms. These are explained in Appendix A. Sources of evidence used in the investigation are listed in Appendix B.

The accident

Summary of the accident

3 At about 10:10 hrs on Tuesday 26 May 2020, at Waterloo Underground station, a passenger stumbled and then fell into the gap between the platform and the northbound Bakerloo line train from which he had just alighted (figure 1). No other people were present to assist or raise the alarm, the passenger was unable to pull himself back onto the platform, and 75 seconds after he fell, the train departed with the passenger still in the gap.

4 The passenger remained motionless on the track after the departure of the first train and, around 85 seconds later, he was hit by a second train entering the station. The passenger received fatal injuries as a consequence of the accident.

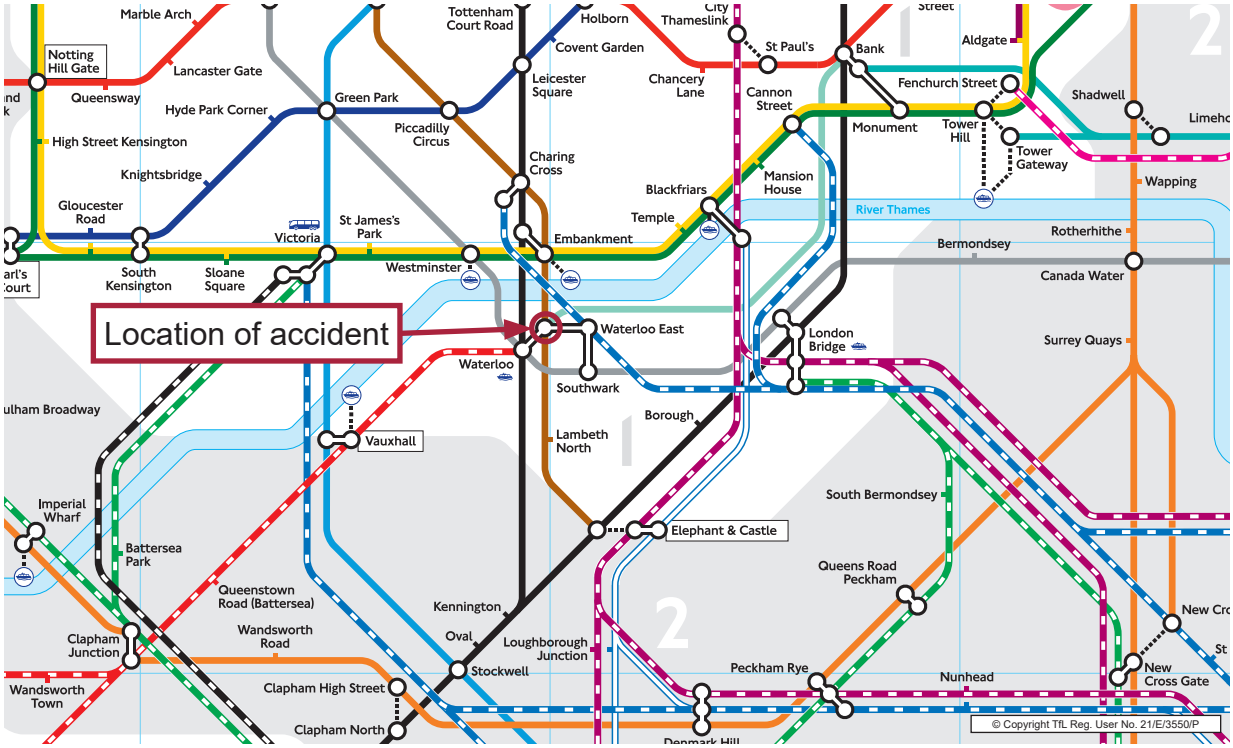


Figure 1: Extract from London Underground map showing location of accident (courtesy of Transport for London)

Context

Location

5 LUL's Waterloo station serves the Bakerloo, Waterloo and City, Jubilee and Northern Underground lines, and provides access to Network Rail's main line station above. The accident occurred on platform 3, the northbound Bakerloo line platform, which is on the right-hand side of trains travelling northwards.

6 The railway is tightly curved to the left (in the direction of travel of trains) through the platform, and this results in larger gaps between the platform and the train in some parts of the platform than would be found at a straight platform (figures 2 and 3). A lineside signal on the approach to the station controlled the movement of trains into the platform area and another signal, about 10 metres beyond the departure end of the platform, controlled movements out of the platform towards the next station.

7 Waterloo Underground station is managed from the supervisor's office located just below ground level, near to the main entrance serving the Bakerloo and Northern lines. The Underground station is equipped with a station CCTV system (paragraph 61). Operations on the Bakerloo line are managed by the Bakerloo line service controllers located in the Bakerloo line Service Control Room.

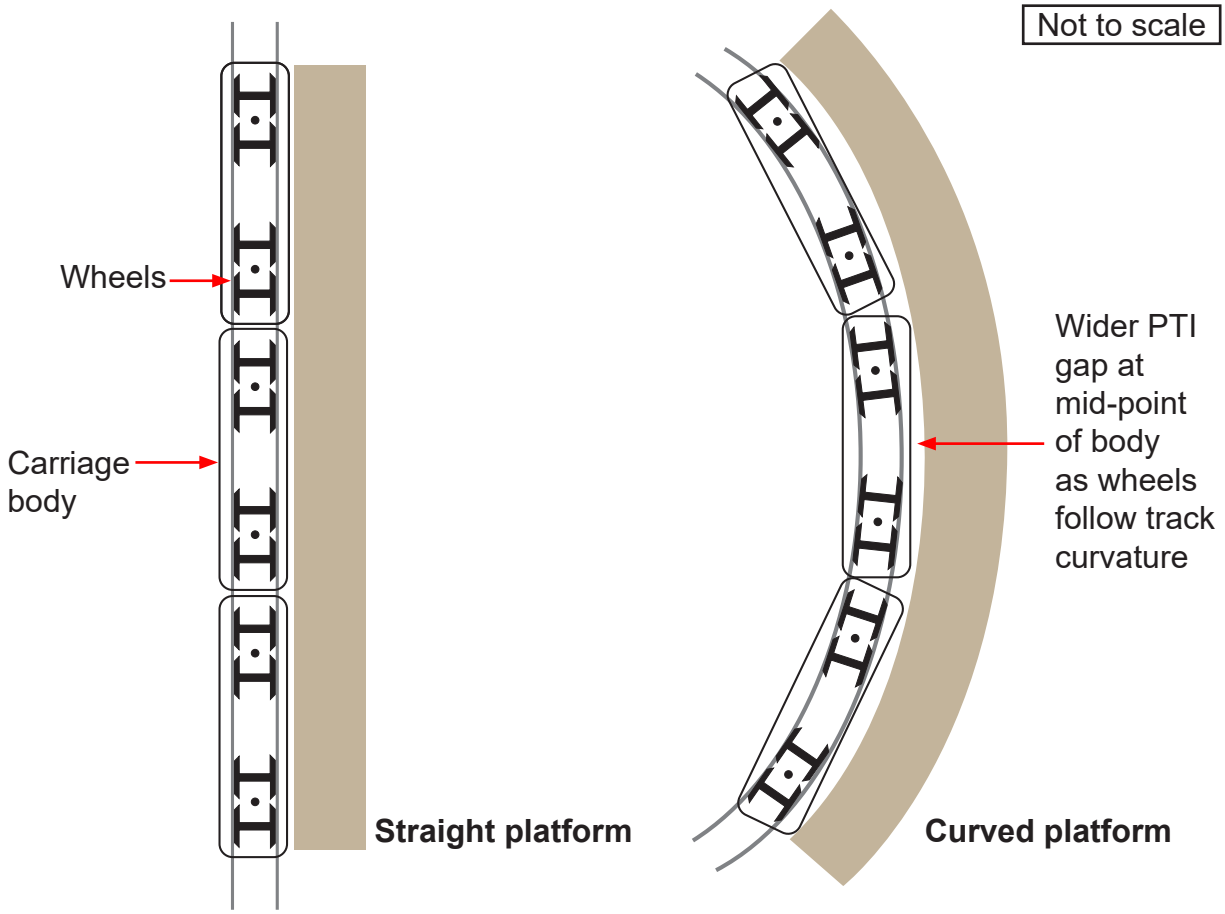


Figure 2: Diagram showing increased gap between the train and platform as a consequence of track curvature

Organisations involved

8 London Underground Limited (LUL), a wholly owned subsidiary of Transport for London, is the infrastructure and rolling stock owner and maintainer. It also operates the trains and is the employer of the staff involved in the accident.

Figure 3: View of Waterloo Bakerloo platform 3 looking south showing the platform curvature and gap between platform and vehicle body

Trains and equipment involved

9 The accident involved two northbound Bakerloo line trains which had begun their journeys at Elephant and Castle station. The first, train running number 210, started its journey at about 10:00 hrs and the second, train running number 214, three minutes later.

10 Both trains were formed of 1972 tube stock and consisted of 3-carriage and 4-carriage units operating as 7-carriage trains. Each carriage is about 16 metres long with two double doorways approximately one-third and two-thirds of the way along the carriage length, and single doorways at each end. The fourth carriage of the incident train incorporated a driving cab, so did not have a single doorway at the leading end (figure 4).

11 Bakerloo line trains are driven manually by a train operator. Train operators undertake platform despatch duties with assistance from either a CCTV system using cameras with platform-mounted monitors positioned in the operator's eyeline, or platform-mounted mirrors targeted on the platform-train interface (PTI). LUL does not require station platforms on its network to be staffed at all times, but defines times when this is needed at some stations. However, LUL had arrangements in place to provide staff on certain platforms at busy times to assist passengers and expedite the flow of people, and the movement of trains in and out of the station. In such circumstances, operators are taught to stop their train if an emergency signal is given by staff on the station platform.

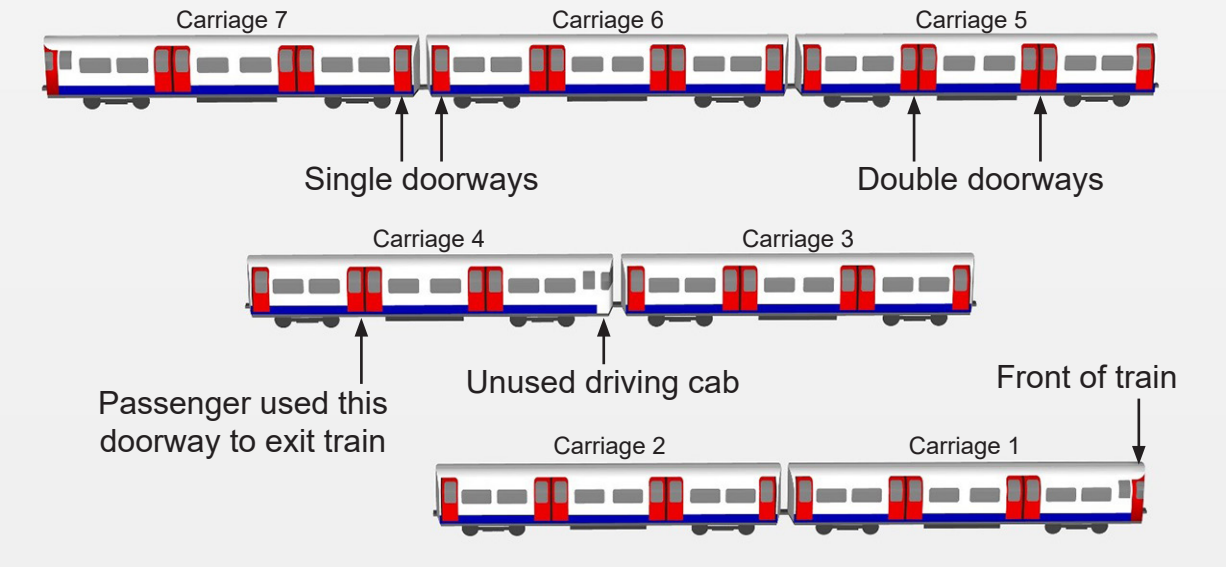


Figure 4: Arrangement of passenger saloon doors on 1972 tube stock trains

12 Platform 3 at Waterloo was equipped with a CCTV system because the track curvature limited the view along the train. This CCTV system was independent of the station CCTV system and comprised six cameras, each feeding a single monitor. The overlapping images on the monitors allowed train operators to view the PTI along the full length of their train. These monitors, known as One Person Operation (OPO) monitors, were located just inside the tunnel mouth at the departure end of the platform (figure 5). In the event of a failure of the OPO system, platform staff must be provided to assist the train operator with the safe despatch of trains.

Figure 5: OPO monitors provided inside the tunnel at Waterloo Bakerloo line platform 3

Persons involved

13 The fatally injured person was a 59-year-old man, Jama Mohamed Warsame, who was travelling back to his home in East London after staying overnight in Lambeth. He was familiar with using the LUL network.

14 The operator of train 210 had joined LUL in October 2016. He initially undertook station duties before training to be a train operator. He qualified as a train operator in April 2019 and, in accordance with normal LUL processes for recently qualified train operators, he was subject to additional monitoring by Trainer Assessors.[1] LUL records show that he had not been involved in any safety-related incidents.

15 The operator of train 214 had joined LUL in May 2014 and undertook station duties at Waterloo before qualifying as a train operator and completing her trainee train operator period in November 2018. LUL records show that she had not been involved in any safety-related incidents.

External circumstances

16 The COVID-19 pandemic meant that few people were using public transport at the time of the accident and this almost certainly affected events (see paragraph 65).

[1] Newly qualified train operators retain the title ‘trainee’ for a period of 14 months after qualifying.

The sequence of events

Events preceding the accident

17 The operator of train 210 was on his second day back on duty after taking a pre-arranged one-month break from train driving. He was due to begin his shift at 08:17 hrs at Queens Park, but his journey to work had been delayed between Baker Street and Queens Park because of the effects of a signal failure further south at Piccadilly Circus. The service disruption was causing delays to northbound Bakerloo line services so, instead of alighting at Queens Park to board a waiting train, he was instructed to make his way to the driving cab of the train on which he was travelling and allow the incumbent operator to take a scheduled break. The train operator drove this train north from Queens Park to Harrow and Wealdstone and then south to Elephant and Castle, where he left the train to join train 210.

18 The passenger entered the underground network at Lambeth North and boarded a southbound train to Elephant and Castle, arriving just before 10:00 hrs. Leaving this service, the passenger asked for directions to East London from a cleaning contractor before heading to the adjacent northbound platform and boarding train 210.

19 At Elephant and Castle, the train operator joined train 210 to drive it north to Harrow and Wealdstone. Due to the signalling problems at Piccadilly Circus the northbound line had become congested, so his train closely followed another service out of Elephant and Castle.

20 The operator of train 214 had booked on at around 07:10 hrs at Queens Park, her first day back at work after three rest days. She had driven a round trip north to Harrow and Wealdstone and south to Elephant and Castle before returning to Queens Park. Her next journey took her south from Queens Park to Elephant and Castle, where she changed trains to join train 214 bound for Stonebridge Park. Train 214 left Elephant and Castle closely behind train 210.

Events during the accident

21 Train 210 travelled towards Harrow and Wealdstone, stopping at Lambeth North and arriving at Waterloo platform 3 around 10:07 hrs.[2] As the train was approaching Waterloo, the train operator heard an announcement on his radio which informed him that signalling problems were likely to delay his departure. After train 210 stopped, the train operator made his passengers aware of the possible delay using the on-board public-address system.

22 Train 210 was held at Waterloo because the signal beyond the platform was at red. In the first three minutes after stopping, three people joined the train. While waiting at the platform, the train operator received a further radio notification about the ongoing signalling issues. After receiving this radio message, he made another announcement to his passengers suggesting that they might wish to seek an alternative route to complete their journeys.

[2] Timings taken from CCTV footage.

23 It has not been possible to determine if this announcement was made before the passenger alighted and, if so, whether it prompted him to get off the train. However, 176 seconds after the train had stopped, the passenger left the train from the rear set of double doors of carriage 4 (the fourth carriage from the front of the train, figure 4). After taking two steps on the platform, moving away from the train, the station CCTV shows the passenger becoming unsteady on his feet, stumbling backwards, and falling into the gap between the platform edge and the mid-point of carriage 4. He fell entirely below the level of the platform at a position where the curvature of the platform is particularly tight and so the gap between the platform and the side of the train was particularly wide (paragraph 6).

24 A few seconds after falling into the gap, the passenger attempted to climb out and draw attention to his difficulty by waving his arms. It is also possible that he called out (sound is not recorded by the station CCTV). His efforts were unsuccessful and he remained in place with only his head and arms above the level of the platform. After struggling for 55 seconds he rested an arm across the white line on the platform edge and remained almost motionless in this position until the train departed 20 seconds later.

25 Around the time that the passenger fell below the level of the platform, a member of public joined the train, followed by another about 40 seconds later. Both entered the platform from an entrance near the headwall (the platform end at the front of the train and about 50 metres from the fallen passenger) and joined the front carriage. Neither person appeared to be aware of the passenger.

26 Around 68 seconds after the passenger fell, the train's doors began to close. The doors took about three seconds to close fully. The train then stood for another four seconds before departing. The passenger was still in the gap between the train and the platform and it is likely that he was struck by the bogie[3] and other equipment mounted beneath the rear of carriage 4, and then by the other carriages of the train. The passenger remained motionless on the track after train 210 had left the station.

27 A member of the public entered the platform from the entrance near to the headwall 44 seconds after the departure of train 210. This person was looking at her mobile phone until the next train (train 214) entered the platform 72 seconds after the departure of train 210. As train 214 approached, she began to run towards the area where the passenger had fallen.

28 Train 214 entered the station normally, but stopped abruptly without the train operator's intervention at 10:13 hrs. The front of the train was short of the normal stopping point and approximately 23 metres beyond the position where the passenger had fallen. The member of the public who was running along the platform reached the train operator's cab at around the same time and attempted to talk to the train operator.

[3] A frame supporting the car body and transferring the body's weight onto two axles, each of which is fixed to the frame with a wheel at each end.

Events following the accident

29 The operator of train 214 was initially uncertain why her train had come to such an abrupt stop and had started losing air from the braking system.[4] After making an initial report to the Bakerloo line service controller, she remained in the cab and began to investigate the loss of air. She was unable to resolve the issue, and made a further report to the service controller before speaking to the member of the public who was at the cab window.

30 The member of the public told the train operator that there was smoke coming from the train, so the train operator made another call to the service controller to report the smoke, secured the train and left the cab to investigate. Walking back along the platform, the train operator realised there was a person under the train and ran back to the cab to inform the service controller and request that the traction current should be switched off.

31 The London Underground Control Centre (LUCC) daily network performance report for 26 May 2020 records the initial reports of smoke at 10:16 hrs and that the service controller had sent a member of station staff to assist. The report notes that emergency services were dispatched. The member of station staff despatched by the service controller can be seen entering the platform area at 10:17 hrs. The traction current was recorded in the log as being switched off at 10:18 hrs.

32 The passengers on board train 214 were de-trained and escorted off the platform using the nearest exit, and the platform access gates were closed. CCTV recordings show the police arriving on the platform at 10:24 hrs followed by members of the fire brigade at 10:27 hrs and the ambulance service at 10:29 hrs.

[4] The brakes on this type of train are operated by an air pressure system with pressure required to release the brakes. A loss of air was caused by the train hitting the passenger and this resulted in the sudden brake application.

Analysis

Identification of the immediate cause

33 The passenger fell between a train and the platform edge before being struck by the train and a following train.

Identification of causal factors

34 The accident occurred due to a combination of the following causal factors:

a. the passenger fell into the gap between the train and the platform and could not get out (paragraph 35); and

b. no intervention occurred because nobody was aware there was a person in the platform-train interface gap when the train departed, or on the track when a second train entered the platform (paragraph 40).

Each of these factors is now considered in turn.

Platform gap

35 The passenger fell into the gap between the train and the platform and could not get out.

36 When the Bakerloo line was constructed at the start of the 20th century, the northbound track alignment through Waterloo station incorporated a tight curve with a radius of between 133 metres and 156 metres. This curve creates a large PTI gap close to the middle of the carriages (figure 6). With a train of this type stationary in the platform, RAIB found the gap to be approximately 264 mm when measured diagonally between the lower corner of the train body and the edge of the platform at the mid-point of the fourth carriage, the area in which the passenger fell (figure 7).

37 The passenger became unstable on his feet and, after stepping from the rear double doorway of carriage 4, stumbled and fell backwards, directly into the PTI gap near the mid-point of this carriage.

38 Once in the PTI gap, the passenger was unable to get out. This was probably at least in part because there was limited space between the platform, the train and the track (figure 8). The task could have been made more challenging by pre-existing mobility limitations which were described (by the passenger's family) as being due to previous leg injuries, any injuries sustained in the fall, or a combination of both.

39 The post-mortem toxicology report recorded a blood alcohol concentration of 360 milligrams of alcohol in 100 millilitres of blood. This blood alcohol concentration is 4.5 times the legal drink-drive limit in England, which is 80 milligrams of alcohol in 100 millilitres of blood. This concentration would cause a high level of intoxication in the average social drinker, most of whom would experience adverse effects including a lack of co-ordination and impaired judgement.

Figure 6: Platform-train interface gap adjacent to carriage 4 at Waterloo Bakerloo line platform 3

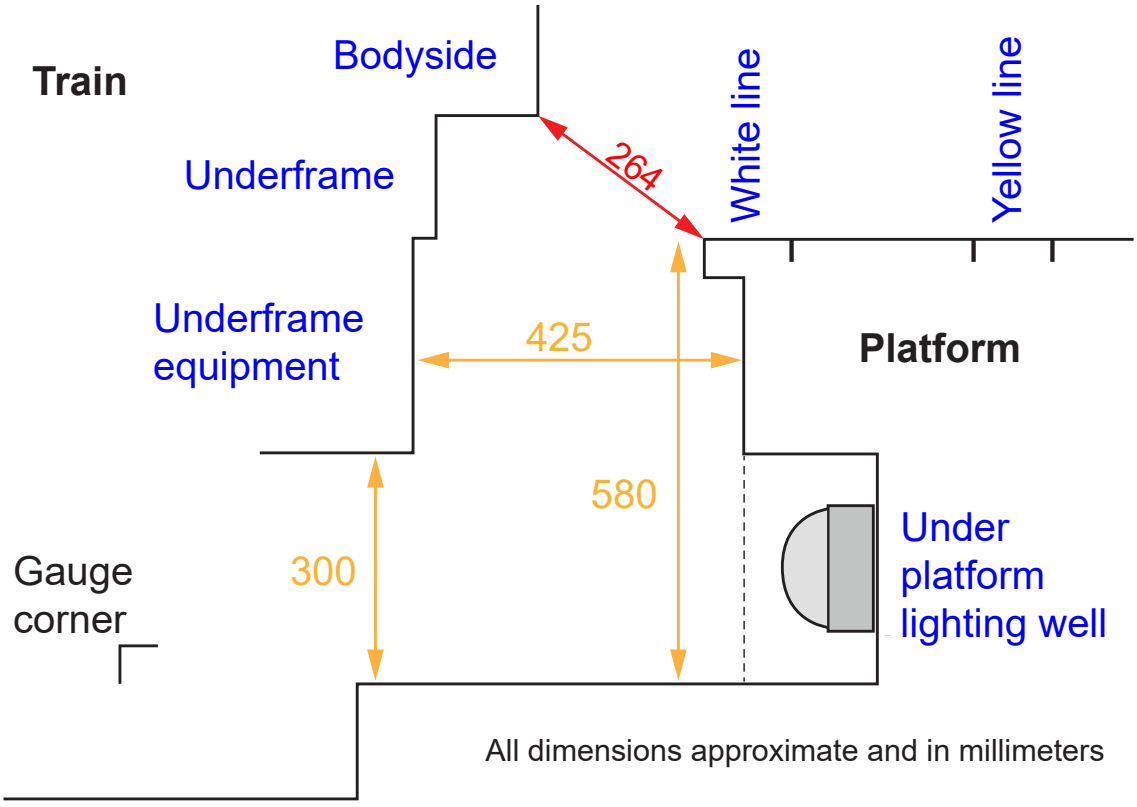


Figure 7: Cross-section between the platform and mid-point of carriage 4 at Waterloo Bakerloo line platform 3

Figure 8: Proximity of under-train equipment to platform edge

Intervention

40 No intervention occurred because nobody was aware there was a person in the platform-train interface gap when the train departed, or on the track when a second train entered the platform.

41 Nobody was aware of the situation for the following reasons:

a. the train operator did not see the passenger fall into the gap, or see the passenger in the gap while checking the platform-train interface before departure (paragraph 42);

b. the operator of the second train did not see the person on the track as their train approached (paragraph 54); and

c. no-one saw the passenger on the track until it was too late to intervene (paragraph 59).

Each of these factors is now considered in turn.

First train

42 The train operator did not see the passenger fall into the gap, or see the passenger in the gap while checking the platform-train interface before departure.

43 As he was arriving at Waterloo, the operator driving train 210 had received a radio message saying that there were signalling problems ahead, and he anticipated a long wait at the station. Train operators were not required by LUL procedures to constantly monitor the platform area for activity during prolonged stops, so the train operator continued to monitor the in-cab radio and the signal ahead of his train while moving about the cab, adjusting his driving seat and the cab temperature controls, and stretching his legs.

44 The passenger emerged from the train about 176 seconds after it stopped and had fallen into the PTI gap less than 5 seconds later. This would have been visible on the OPO monitors, but the train operator saw nothing unusual during his prolonged stop at Waterloo station. It is probable that the passenger fell while the train operator's attention was away from the OPO monitors.

45 The train despatch was undertaken by the train operator using the platform images provided by the OPO monitors and without assistance from other staff (none were on the platform, see paragraph 60). The LUL Rule Book[5] requires that train operators performing the despatch process must:

a. check the station starting signal is clear

b. check the entire platform-train interface

c. close the doors and check the doors closed visual [6]

d. check the entire platform-train interface again

and must then:

e. check that the station starting signal is still clear

f. make a final check of the platform-train interface

g. start the train

h. check the in-cab monitors (if fitted) as the train leaves the platform *[not applicable to trains operating on the Bakerloo line]*.

46 LUL has explained that train operators are trained to scan the OPO monitors for anomalies such as persons close to or caught by the train, as well as people running across the platform towards the train. LUL has stated that the standards and guidance are focused on spotting anomalies on and above platform level, so OPO monitor images are optimised for this purpose.

47 At Waterloo Bakerloo line platform 3, the six OPO monitors that allow train operators to view the full length of the PTI (paragraph 12) were positioned behind a glass screen approximately 3.2 metres from the train operator's driving position (station CCTV images show that train 210 had stopped in the correct position at the time of the accident). The monitors are inspected each morning to confirm that the cameras are correctly aligned and the images are displayed distinctly. The monitors were checked at 04:55 hrs on the day of the accident and no defects were recorded.

48 The images displayed by the OPO system are not recorded, so LUL, with RAIB in attendance, undertook a simulation of the situation when the train operator decided to despatch train 210. For the simulation, the position of the passenger when the train operator closed the train doors was determined from station CCTV images and then replicated using a mannequin to allow photographs to be taken of the images displayed by the OPO monitors (figure 9).

[5] London Underground Operational Standards Rule Book 8: Managing the platform train interface (issue 5).

[6] An indicator light in the cab showing that train doors are closed.

49 At the time of despatch, the image of the passenger would have been in the top left-hand corner of the top right OPO monitor. The passenger was wearing dark clothes and only his head and arms were above platform level. One of his arms was out across the platform and this arm would have been the only part of his body visible on the OPO monitor. Given these factors, the simulation showed that it would have been very difficult for the train operator to detect the passenger. RAIB photo-edited an OPO monitor image to show there would be little difference in image with and without the passenger's arm and head above the platform (figure 10).

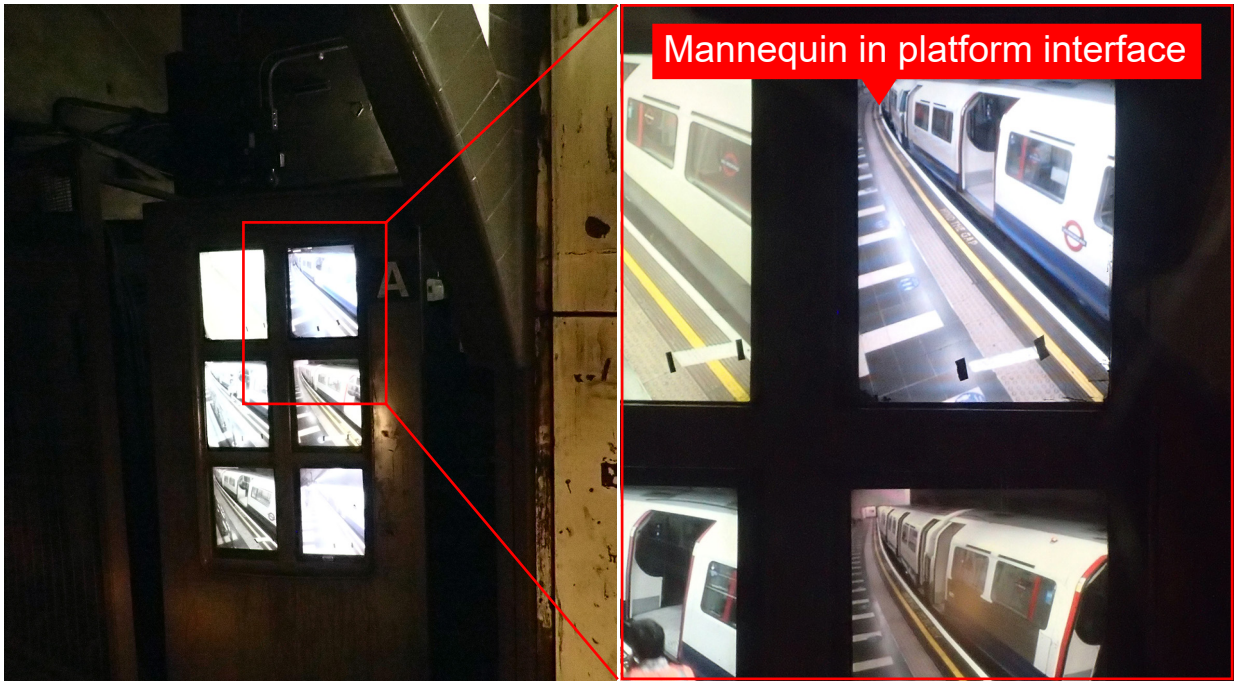


Figure 9: Layout of OPO monitors and position of passenger during despatch adopted by mannequin as would have been presented to operator of train 210 (inset)

Figure 10: OPO monitor images

50 To compare the image seen with only a passenger's arm above the platform, and the image seen when a person is standing on the platform at the same location, RAIB photo-edited an OPO monitor image to show how a 1.83 metres tall person would appear on the OPO monitor. The standing person is considerably more apparent (figure 10). LUL's formal investigation into this fatal accident also found that the OPO monitors, although fit for identifying incidents above platform level, were not suitable for detecting unsafe events in the PTI gap such as those which occurred in this accident.

51 LUL has stated that the OPO monitors were installed in the late 1980s, at least seven years before a new standard[7] for OPO mirrors and monitors was introduced in 1997. When introduced, this standard required that a person of 1.83 metres height should appear greater than 45 mm high on the applicable monitor image. This requirement was revised in 2003 to require a 1.6 metres person standing on the platform to be not less than 10% of the overall monitor height.

52 RAIB measured the height of the monitor image at Waterloo and found that a 1.83 metres person, at the furthest point from the camera, would appear about 28 mm high and a 1.6 metres person would be about 7.2% of the overall monitor size. LUL has stated that, in accordance with its processes,[8] new standards are not applied retrospectively unless a safety shortcoming is identified.

53 A replacement OPO platform CCTV system, compliant with the 1997 standard (or the 2003 revision), combined with more modern cameras and monitors, would have provided a larger and higher quality image. Although this would have improved the conspicuity of the passenger's arms across the platform white line, it is likely that the passenger's dark-skinned head would have remained difficult to distinguish against the dark background. Given that the image of the passenger's arm(s) would still occupy only a very small fraction of a monitor screen that was located 3.2 metres from the driving position, it is uncertain, but considered unlikely by RAIB, that the train operator would have noticed the presence of the passenger had more modern cameras and monitors been installed in the same positions as the current equipment.

Second train

54 The operator of the second train did not see the person on the track as their train approached.

55 Around 85 seconds after the first train departed, the passenger, who was motionless on the track within the platform area, was hit by train 214. The left-hand curve through the station would have restricted the train operator's view of the passenger until the train was about 50 metres or 7 seconds away.

56 Train 214 had been held at a signal on the approach to Waterloo station because of train 210's extended station stop caused by signalling problems further along the line. When the signal cleared to a proceed aspect, the operator of train 214 accelerated towards the station. The train operator stated that she was not used to accelerating towards Waterloo station as it was unusual to be held at the signal outside the station. A more normal journey would require the operator to coast or brake as they left the tunnel and entered the station.

[7] CSE-SCS-ST0002 System standard for OPO Monitors and Mirrors.

[8] Safety Certification and Safety Authorisation, version 5.5 - Section 14.5 'Asset design pre-dating current standards'.

57 As the station came into view, the train operator looked across the platform to identify any unusual activity. Train operators are trained to look for situations which might become dangerous such as people running towards, or standing too close to, the platform edge. Following another train so closely, and seeing the platform was empty, the train operator switched her attention to bringing the train to an accurate stop.

58 The train operator stated that she had sometimes experienced a small and sudden change in train speed (described by her as a 'kick' or 'push') in the last stages of arriving at Waterloo platform 3, and did not wish to overshoot her stopping point. Consequently, her attention was switching between the platform, the distance to her stopping point and the speedometer, so she did not see the passenger before the train came into contact with him. It should be noted that trains on LUL, just like mainline trains, are not driven 'line-of-sight'. Their movement is controlled by signals and, if a train operator passes a signal showing a proceed aspect, as in this instance, the line ahead is considered to be clear to the next signal. The train operator's description of the objects of her attention as the train was approaching its stopping point in the platform are therefore not contrary to LUL rules and training.

Station supervision

59 No-one saw the passenger on the track until it was too late to intervene.

60 LUL procedures did not require station staff to assist train despatch, or to be present on platform 3, at the time of day when the accident occurred. This was unaffected by the COVID-19 pandemic which had resulted in reduced staff attendance at other times when the platform would normally be busy and staff would be present.

61 A CCTV system is provided throughout the station for the general management of public areas, with monitors situated in the station supervisor's office. This CCTV system has 375 cameras distributed around the station, including on the platforms, and images are recorded. It is not connected to the system used for the OPO monitors.

62 There are two CCTV workstations in the station supervisor's office, each comprising three 'quad-split' overview screens, so each workstation can show twelve images (figure 11). The system is configured such that the image captured by each camera will appear for approximately five seconds in sequence. This automatic refresh sequence can be interrupted by many triggers such as an alarm or fire door being opened, which LUL states is a frequent occurrence. There is also an additional detail monitor at each workstation which can show any one of the camera images at the request of the system operator.

63 Camera 181 of the station CCTV system is on Bakerloo line platform 3 and captured the whole accident sequence, including the period between the departure of train 210 and the arrival of train 214. It is probable, but not certain, that part of this sequence was shown on the system monitors, but if so, it is not known if this would have been in time to stop train 210 from departing or to stop train 214 from entering the station area.

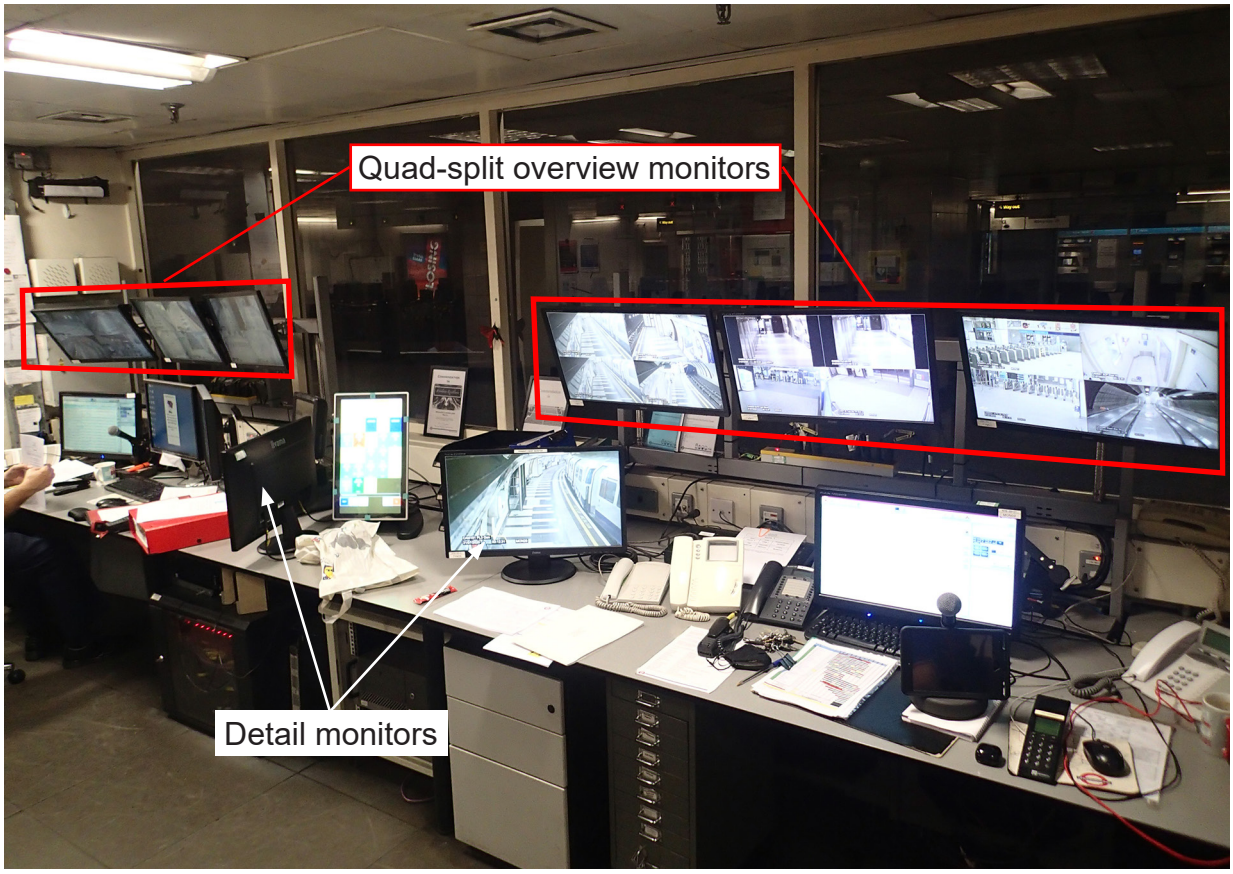


Figure 11: CCTV workstations at Waterloo station control room

64 LUL has stated that staff in the station supervisor's office are not required to be continuously monitoring the CCTV system, nor are they responsible for supervising the PTI gap or taking part in the despatch process. The station CCTV system allows staff responsible for managing the station to observe events as they occur, for example passenger flows during busy periods. Recordings from the system allow investigation of reported events such as criminal acts and accidents. When using the Waterloo CCTV system, the user's attention would not normally be focused on the PTI of the eight LUL platforms. There is no evidence that station supervision staff witnessed the accident. If an unsafe event requiring a train to be stopped is seen on the CCTV monitors, station supervision staff are expected to get the train stopped by contacting the Bakerloo line service controller or, when in attendance, members of staff on the platform.

65 Because of the COVID-19 pandemic, there were very few members of the public using the London Underground network at the time of the accident. There was no-one on the platform when the passenger fell, and only two people used the platform after he fell (paragraph 25) and before train 210 departed. Both these people entered the platform and boarded train 210 at a place where the curvature of the platform would have prevented them seeing the fallen passenger. Any call for help would need to have been heard over background noise, and the acoustics of the station, which is unlikely at that distance.

66 Only one person used the platform between the departure of train 210 and the arrival of train 214 (paragraph 27). This passenger was looking at her mobile phone and appears to have been unaware of the accident until it was too late to prevent train 214 reaching the person on the track.

Identification of underlying factors

PTI risk management

67 LUL had not fully quantified the level of risk on platform 3 at Waterloo station and, as a consequence, had not fully considered additional measures to reduce the likelihood of people falling down the gap and remaining undetected at this location. This is a possible underlying factor.

68 Some parts of LUL risk management processes did not take into account the differing levels of risk at different stations when considering the risk of a passenger falling into the PTI gap. Platform markings, lighting within the gap and 'mind the gap' announcements are evidence that the particularly large gap caused by platform curvature had been recognised as a risk. However, LUL's formal risk assessment processes did not identify the gap at curved platforms as a greater risk than at stations with straight platforms and, as a result, these processes would not trigger full consideration of possible mitigation measures.[9]

69 RAIB's examination of LUL's management of risk at Waterloo platform 3 concluded:

- the risk assessment processes used by LUL did not fully assess the factors that influenced PTI risk at individual platforms, and so did not identify any need for additional risk control measures for curved platforms such as platform 3 (paragraph 70);
- LUL's PTI strategy recognised the risk of people falling into the gap between trains and platforms at curved platforms, but did not give appropriate consideration to associated risk mitigation measures (paragraph 83).

Quantified risk assessment

70 LUL quantified operational risk using the London Underground Quantified Risk Assessment (LUQRA). The risk to passengers was calculated by a mathematical model of the network within the LUQRA comprising two parts. The first determined the likelihood of an undesirable event, and the second considered the consequences.

71 Figure 12 shows the fault tree analysis used by LUL to determine the likelihood of an incident resulting in a customer falling between the train and platform somewhere on the Bakerloo line. This fault tree analysis was last updated in 2017 and used historical data to assess the frequency of customers falling into the gap between train and platform on the Bakerloo line.[10] This was assessed as contributing two occurrences per year, which were combined with 12.67 occurrences of falls when passengers were boarding or alighting, to give a frequency of 14.67 occurrences per year for passengers falling into the gap between a train and a platform on the Bakerloo line.

[9] RAIB has not sought to establish what, if any, additional controls would have been justified in these circumstances. RAIB has established only that the additional risk should have been properly recognised and quantified, with the consequent possibility this could lead to additional controls.

[10] The type of event which occurred on 26 May 2020 would be described in the fault tree analysis as: 'customer falls between train and platform into gap while not stepping on or off the train, or where there is insufficient data to determine if the passenger involved was boarding or alighting'.

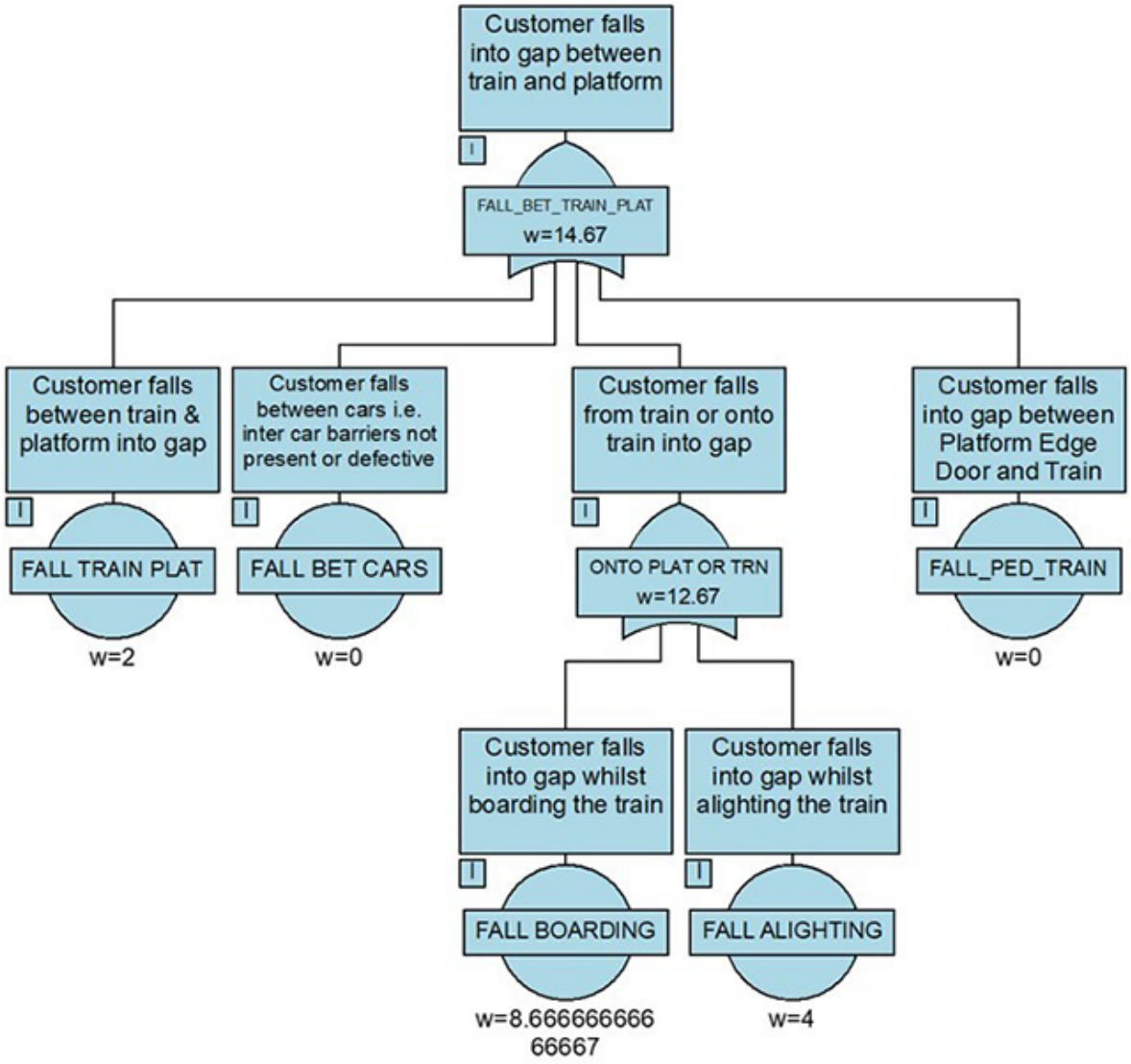
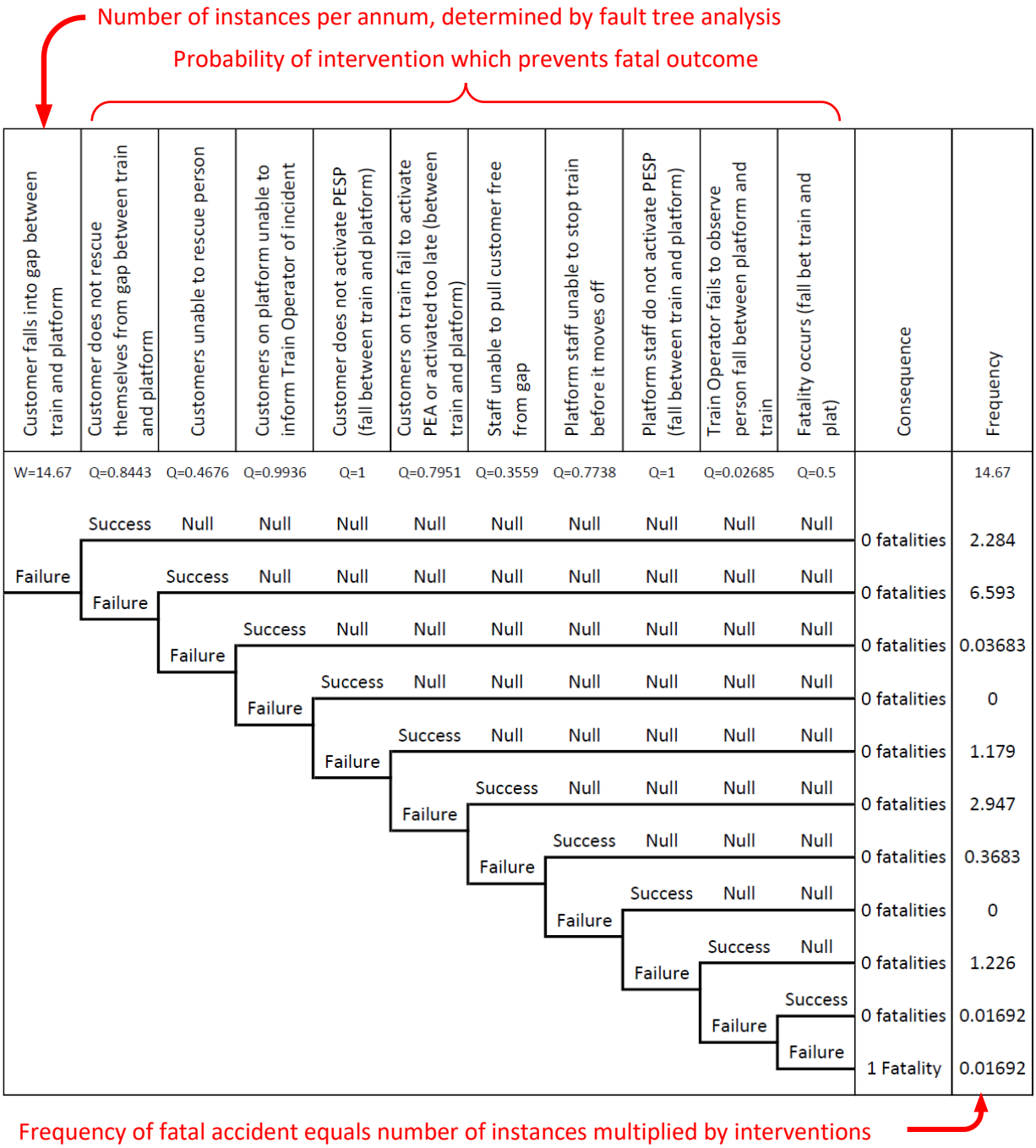


Figure 12: LUQRA fault tree analysis used to calculate likelihood of a fall into the PTI gap on the Bakerloo line

72 The severity of the consequence, expressed as a number of fatalities per annum, was determined by event tree analysis which considered possible interventions to prevent a death arising from a particular event. The likelihood of an intervention preventing a fatality is derived from a combination of historical incident data, consequence analysis (where this is available) and expert judgement from within LUL.

73 Figure 13 shows how interventions relating to falls into PTI gaps on the Bakerloo line (calculated as 14.67 occurrences per annum) would lead to a train starting to move with a person in the gap on 0.03384 occasions annually. The LUQRA model assumed that half of these, 0.01692 instances a year, would result in a fatality, the equivalent to one fatality every 59 years.

74 Although the LUQRA had been prepared before the accident on 26 May 2020, it did incorporate another Bakerloo line accident on 27 September 2015 (see paragraph 93) which also resulted in a fatality. These events appear inconsistent with the risk quantified in the LUQRA. It is uncertain whether this apparent inconsistency reflects an underestimate of risk, a statistical anomaly due to the small numbers involved, or a combination of both.



For example, the probability of a customer not rescuing themselves being 0.8443, thus the probability of them rescuing themselves is 0.1557, equivalent to 2.284 occurrences per year (0.1557 x 14.67 = 2.284).

The failure probabilities for each of the interventions in the event tree are not independent. The failure probability for each intervention is calculated assuming the previous interventions have already failed to prevent the incident escalating.

Figure 13: LUQRA event tree analysis used to calculate the outcome of a fall into the PTI gap on the Bakerloo line

75 By combining the results from the LUQRA models for all lines, LUL estimated that the total PTI risk on its network was 1.95 fatalities per annum. This was 29.1% of the total network risk and represented the highest single category of risk on its network.

76 The LUQRA model does not enable the identification and detailed assessment of those factors that contribute to higher PTI risk at certain platforms. Consequently, the LUQRA did not provide an estimate of the contribution of curved platforms to the overall PTI risk, and so was unable to highlight locations where that risk factor was of particular concern.

77 In response to an improvement notice issued in October 2020 by the Office of Rail and Road (ORR) (see paragraph 107), LUL assessed the risk from passengers falling into the gap at Waterloo platform 3 to be 0.1165 fatalities and weighted injuries[11] (FWI) per annum; this is roughly equivalent to 1 fatality and 1 major injury every ten years (or eleven major injuries over a ten-year period). By way of comparison, at the time of the accident, the LUQRA model's estimate of risk for all types of fatal accidents at the PTI on the entire Bakerloo line was 0.111 fatalities per annum (one fatality in 9 years). The LUQRA model also estimated that the risk of passengers falling into the gap between train and platform on the Bakerloo line was 0.01692 fatalities per annum (one fatality in 59 years, paragraph 73).

78 The 2020 assessment carried out in response to ORR's improvement notice appears to suggest that the risk due to falling into the gap at platform 3 (0.1165 FWI per annum) is nearly as great as the risk that had been previously estimated by the LUQRA for all PTI risk on all 52 platforms on the Bakerloo line (0.111 fatalities per annum). If both estimates are correct, the risk of falling into the gap on platform 3 at Waterloo accounts for the majority of the total PTI risk on the Bakerloo line. This seems most unlikely given the number of other PTI risks and the existence of other potentially high-risk platforms on the Bakerloo line, including platform 4 at Waterloo.

79 Since the LUQRA model calculates the risk of fatal accidents, and does not include the risk of injuries, its results cannot be directly compared with the 2020 risk assessment for Waterloo platform 3 (more detail of LUL's approach to calculating the risk of harm is given at paragraphs 88 to 92). Furthermore, the LUQRA was last updated in 2019, before the accident on 26 May 2020, and therefore takes no account of this fatality in its estimates of risk for the Bakerloo line. However, the outcome of the 2020 risk assessment for platform 3 suggests that the overall PTI risk on the Bakerloo line is probably higher than previously estimated and reinforces the need for LUL to focus its attention on stations with tightly curved platforms.

[11] Fatalities and weighted injuries (FWI) is a composite measure of risk or harm that combines fatalities with physical injuries and cases of shock/trauma, which are weighted according to their relative severity.

Local risk management

80 LUL used the LUQRA to quantify and manage the likelihood of a passenger fatality on a line-by-line and network-wide basis. This assessment was supplemented by a localised assessment of risk to customers on a station, or group of stations. Known as the Customer Risk Assessment (CRA), it considered the probability of harm to station users including risks from the PTI and events not directly linked to trains, such as falls on escalators or stairs. LUL states that CRAs assess risk using historical incident data relevant to the location being assessed, together with the expected effects of applying standards, staff training and information provided to customers among a number of other mitigation measures.

81 There were two CRAs relevant to this accident, one covering the Bakerloo line, and the other considering the entire Waterloo Underground station. Neither assessment documented consideration of the risk on individual platforms or mentioned the size of the gaps between trains and certain platforms caused by the line curvature. LUL state that 12.3 million passengers per annum use platform 3 at Waterloo, and there had been 15 incidents of passengers falling into the PTI gap between April 2017 and March 2020. Although no injuries were reported for eight of these incidents, seven were reported as resulting in minor injuries. There had also been a number of previous incidents of people falling down the PTI gap, including a fatal accident in 2015, on the Bakerloo southbound line (see paragraphs 93 to 96).

82 The LUL investigation into the fatal accident which occurred at Waterloo in 2015 recommended a review of the CRA process, in particular the consideration of risk at individual platforms and the use of quantifiable data by risk assessors (see paragraphs 97 and 98). However, it is uncertain if LUL's recommended changes to the CRA process would have resulted in substantive change to platform 3 at Waterloo without significant change to the LUQRA. Changes to the LUQRA had not been included in the LUL recommendations.

PTI Strategy

83 In 2016, LUL published its PTI Strategy document, a three-year plan intended to trigger a year-on-year reduction of risk as part of a PTI risk reduction initiative. The plan was updated in 2018 and underwent a progress review in August 2019.[12] LUL established working groups to review PTI risk on a line-by-line basis and the Bakerloo line group discussed the increased risk at the curved Waterloo platforms. This group looked at the age of the OPO monitors in 2017, making a request that this should be reviewed and also recommended that train operators make announcements to passengers about the PTI gap at Waterloo. Awareness and good practice for the management of PTI risk was shared across all lines by the participation from line-based representatives in a PTI network-wide steering group.

[12] 'Platform Train Interface Strategy Review 2018 - Review 2 of Our Three Year Plan Reviewed dated August 2019'.

84 The PTI risk reduction initiative identified the need for improvements to the images provided to train operators on OPO monitors, and a review programme was put in place with the intention of incorporating the 2017 working group request relating to the age of the OPO system (paragraph 83). For the Bakerloo line, this review led to changes to camera alignments to improve visibility of the PTI to train operators during busy periods. The review also proposed further changes to the OPO cameras at Waterloo which were scheduled for implementation in December 2021, a timescale which LUL stated was based on safety risk to the customer. These changes would have been unlikely to affect the ability of train operators to detect people who have fallen fully into the PTI gap. The review did not include consideration of the age and suitability of the CCTV equipment, despite the system pre-dating the relevant standards (paragraphs 51 and 52).

85 The initiative has triggered improvements intended to reduce the risk at the PTI at certain high-risk stations, such as changes to the platform markings and track positioning relative to the platform, and other initiatives such as passenger behaviour studies for consideration in the future.

86 The initiative did identify the additional risk posed by curved platforms and considered the use of gap fillers to reduce the PTI gap. The railway industry has previously explored the use of movable gap fillers which extend out from the platform to close the widest PTI gaps associated with the centre (or ends) of carriages, and then retract before the train moves. LUL stated, in the PTI Strategy Review, that no existing gap filler was considered appropriate for use on its network, but an alternative bespoke solution would be explored.

87 Controls which might prevent PTI accidents in circumstances other than those seen on 26 May 2020 are identified within the PTI Strategy Review document, but it does not identify the potential benefits, or the likely costs that would be necessary for a quantified assessment. The PTI strategy initiative has not resulted in implementation of any change which might have reduced the probability of this accident at the northbound Bakerloo line platform at Waterloo.

Observations

Estimation of harm

88 Although not linked to the accident on 26 May 2020, RAIB observes that the model used by LUL to quantify system risk (the LUQRA) makes no allowance for non-fatal injuries, and so understates the risk of harm to passengers at the PTI.

89 LUL describes the purpose of the LUQRA as promoting an understanding of risk on its network, and for each of its lines. LUL's document which summarises the purpose and results of the model describes the LUQRA as providing:

> *"… a basis for identifying whether adequate controls are in place, or whether further reasonably practicable risk controls are required."*

> *"… a valuable base line measurement of current levels of risk, against which any proposed change to equipment, procedure, organisation or any other aspect of operation can be judged in terms of its effect on safety"*

90 The LUQRA risk estimates are based on the predicted number of fatalities for a range of dangerous events, which includes accidents at the PTI. However, the model does not account for injuries which do not lead to a loss of life, so underestimating the total potential for harm.[13] This underestimate is likely to be significant for risk to passengers on platforms given that most accidents at the PTI do not result in a fatality, although some may cause major injury (paragraph 95).

91 RAIB has seen evidence that when carrying out risk assessments to inform a specific safety decision (such as the introduction of new technology), LUL has also used alternative quantified techniques that do make allowance for fatal and weighted injuries as part of safety cost/benefit analysis.

92 Although LUL has sometimes adopted risk assessment tools that allow for fatal and weighted injuries, RAIB observes that the LUQRA presents an incomplete picture of system risk that has the potential to affect LUL's safety decision making.

Previous occurrences of a similar character

93 On 27 September 2015, a passenger was fatally injured after falling in the PTI gap on the southbound Bakerloo line platform at Waterloo (platform 4). The passenger had alighted and moved away from the train before falling back into the PTI gap at the mid-point of a carriage on a tightly curved line.

94 It is probable that the passenger had suffered a medical episode and had lost consciousness before the fall, which occurred around the time the train operator had applied traction power to start the train. The train was stopped by the activation of an on-board passenger emergency alarm. On the basis of these facts, RAIB did not undertake further investigation.

95 A formal investigation undertaken by LUL noted the 'larger than normal' PTI gap and that 17 incidents of passengers falling into the PTI gap had occurred at that platform since 2005, most resulting in minor injuries, but with one major injury.

96 The LUL investigation also noted that the LUQRA did not identify individual platform risk and not all instances of persons falling into the PTI gap had been captured within the historical data used to inform the CRA process. The LUL report stated that the window of opportunity for the train operator to see and react to the event was too short to prevent the accident.

97 Several recommendations were made, with recommendation 5B of the LUL investigation being directly relevant to this investigation and stating:

The Customer Risk Assessment process shall be reviewed by the 'HSE [Health, Safety and Environment] Transformation Project' with particular attention to the following items identified from this FIR [Formal Investigation Report]:

A. The use [sic] available quantifiable data by Risk Assessors to assess the risk to passengers.

B. All platforms to be considered on an individual basis rather than the present Line or Station basis.

[13] LUL's Safety Decision Making standard required that, when undertaking a quantitative cost-benefit analysis using LUQRA estimates, the potential benefits from avoiding non-fatal injuries should be included by multiplying the number of fatal injuries calculated using the LUQRA by a specified factor. This factor was 1.0 for PTI incidents, meaning that no account was taken of benefits from avoiding non-fatal injuries at the PTI.

98 The action target date was recorded as ‘Completed’. LUL has stated that this status was assigned to the recommendation after including it within a wider review of risk assessment processes. However, the CRAs that applied at the time of the accident did not include quantified data or an assessment of each platform. Therefore, the intent of LUL’s recommendation had not been met.

Summary of conclusions

Immediate cause

99 The passenger fell between a train and the platform edge before being struck by the train and a following train (paragraph 33).

Causal factors

100 The causal factors were:

a. The passenger fell into the gap between the train and the platform and could not get out (paragraph 35, no recommendation).

b. Nobody was aware of the situation for the following reasons:

i. The train operator did not see the passenger fall into the gap, or see the passenger in the gap while checking the platform-train interface before departure (paragraph 41a, **Recommendation 1**).

ii. The operator of the second train did not see the person on the track as their train approached (paragraph 41b, no recommendation).

iii. No-one saw the passenger on the track until it was too late to intervene (paragraph 41c, **Recommendation 1**).

Underlying factors

101 A factor possibly underlying the accident was that LUL had neither fully quantified the level of risk on platform 3 at Waterloo station nor considered additional measures to reduce the likelihood of people falling down the gap and remaining undetected at this location (paragraph 67, **Recommendations 1, 2 and 3**).

Additional observations

102 Although not linked to the accident on 26 May 2020, RAIB observes that the model used by LUL to quantify system risk (the LUQRA) makes no allowance for non-fatal injuries, and so understates the risk of harm to passengers at the PTI (paragraph 88, **Recommendation 2**).

Previous RAIB recommendations relevant to this investigation

103 The following recommendation, which was made by RAIB as a result of a previous investigation, has relevance to this investigation.

Passenger trapped in train doors and dragged at Clapham South station, 12 March 2015, RAIB report 04/2016, Recommendation 1

104 This recommendation read as follows:

Recommendation 1

London Underground should review the feasibility and effectiveness of measures to reduce risks associated with passengers being trapped in train doors and then dragged at the platform-train interface (PTI). The review should include measures already considered for all or part of the London Underground network, techniques already used by other railway operators, measures already considered by RSSB and measures made possible by the latest technology available when the review is undertaken. The review should include, but not be restricted to, consideration of:

- *improving detection of objects trapped in train doors;*
- *improving the ability of passengers to pull out objects trapped in doors (including by improving door seal arrangements);*
- *improving train operator views of the PTI at despatch (eg increasing the number of CCTV cameras, repositioning cameras and providing larger monitors);*
- *enhancing the methods available to staff performing station assistant (train services) duties when they need to alert train operators, or stop trains, in an emergency;*
- *using gap fillers or alternative means to reduce the gap between platforms and both moving and stationary trains;*
- *adapting platform markings to reduce passenger crowding close to trains/ doors; and*
- *raising passenger awareness of the safety risks associated with objects, fingers and hands becoming trapped in doors.*

The review should conclude with a time-bound, funded plan for progressing development of potentially viable measures. This should, if appropriate, include solutions which are only applicable to some parts of the London Underground network.

105 ORR reported to RAIB on 8 March 2017 that LUL had implemented this recommendation. The actions taken by LUL in response included the publication of the platform-train interface risk management strategy (paragraph 83) and the initiation of an extensive project to improve train operators' views from platform CCTV cameras. These CCTV improvements were not targeted at identifying people who had fallen into the PTI gap (paragraph 42).

106 LUL recorded in its own formal investigation into the 26 May 2020 accident that 'significant work' had been undertaken to address this recommendation, and that it has been complied with. The LUL investigation also identified that further review of CCTV arrangements at the PTI and the use of gap fillers would be worthwhile. This could contribute to implementation of Recommendation 1 (see paragraph 110).

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

107 On 29 October 2020, ORR served LUL with an improvement notice relating to the Bakerloo line platform 3 at Waterloo. ORR reported that LUL had complied with the improvement notice before the 15 December 2020 compliance date. The following summary is taken from the ORR improvement notices webpage:[14]

> *This notice was served as London Underground Limited failed to make a suitable and sufficient assessment of the risks to the safety of any persons who may fall into the gap between the platform and train at platform 3, for the purpose of identifying the measures needed to ensure the safe operation of the Bakerloo line at Waterloo station and implementing the identified measures. London Underground Limited also failed to record the assessment process undertaken and the significant findings of the assessment. They failed to ensure, so far as reasonably practicable, the safety of persons not in their employment at the platform-train interface of platform 3 of the Bakerloo line at Waterloo Underground Station.*

108 LUL responded to the improvement notice and confirmed that the Customer Risk Assessments have been updated so as to:

- add control measures which are specific to platform 3 to both CRAs and provide clearer information on the significant specific contributory factors that might lead to a customer fall between the train and the platform on platform 3;
- make the CRA clearer on the individuals who might be harmed, including vulnerable groups of people and how they might be harmed and the control measures in place that are specific to managing any increased risks to those customers;
- include greater detail on any specific areas of higher risk that might be relevant to a person(s) falling into the gap between the platform and train, such as the larger gaps between the train and the platform on curved Bakerloo line platforms;
- include greater detail on the assessment of the different specific risks that might arise in relation to this platform and which might lead to a person falling between the train and platform, such as the larger gaps between the train and the platform on curved Bakerloo line platforms and greater detail about contributory factors, including travelling while intoxicated and vulnerable customers;
- include further information on the likelihood of a fall down the gap to inform the risk rating in the CRA;
- add greater detail and clarity on potential incident severity for each risk;
- restructure the CRAs to ensure that the order of controls follows the hierarchy of controls; and
- ensure that there is greater consistency between the Waterloo station CRA and the Bakerloo line CRA.

[14] https://www.orr.gov.uk/monitoring-regulation/rail/promoting-health-safety/investigation-enforcement-powers/our-enforcement-action-date/improvement-notices/2020.

109 LUL's December 2020 response to the improvement notice also stated that, following a recommendation made as part of its own formal investigation into this accident, it had started a review of its current process for assessing PTI risks and documenting controls for the entire network. The review was to consider RSSB[15] guidance and any other good practice from the rail sector with a view to identifying improvements to LU's approach to managing PTI risk. It would also explicitly consider how LUL manages risks associated with situations where someone has fallen between the train and the platform (including the train operator's ability to identify these situations). Since the December 2020 response, LUL has stated to RAIB that the review has been completed.

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

Recommendations

110 The following recommendations are made:[16]

1 *The interface between platform and train (PTI) presents various risks to passengers and, although most are found on all platforms, some platforms present additional or enhanced risk because of specific features such as track curvature creating a significantly higher risk of a person falling below the platform level. The intent of this recommendation is to recognise and assess location-specific risks so they can be properly managed. Reference to RSSB guidance on risk management at the platform-train interface is likely to assist implementation of this recommendation*.

London Underground Limited should carry out and document a suitable risk assessment of each tightly curved platform on its network, and any other locations at which passengers are considered to be at particularly high risk due to characteristics of the platform. In each case, this should include consideration of:

- the platform-train gap at all positions along the vehicle body;
- the influence of low, normal and high passenger numbers;
- the train operator's visibility of the PTI during despatch;
- the safety of vulnerable passengers;
- opportunities to expand the use of incident data to improve risk assessments;
- potential engineering measures to prevent access to the gap, to reduce the gap, and/or to detect the presence of people in the gap; and
- non-engineering measures to reduce the likelihood of people falling into the gap and to mitigate the consequences if they do so.

London Underground Limited should develop a timebound programme for the implementation of any additional control measures that are justified (paragraphs 100 and 101).

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[16] 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 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.

2 *The intent of this recommendation is to provide those who are responsible for managing risk with reliable risk assessment data that enables them to identify those locations on its network where the risk of harm is highest and to better inform their decisions on the need for additional risk mitigation measures.*

London Underground Limited should review and update its quantified system risk model (LUQRA) to ensure that it is consistent with:

- current good practice in the rail industry;
- achieving a better understanding of how risk is distributed across its rail network;
- identifying potentially high-risk locations that warrant more detailed risk assessment;
- providing useful risk information to those with the responsibility for the safety of individual lines and stations;
- understanding the entire risk of harm, including that associated with non-fatal injuries; and
- the systematic evaluation of whether additional safety measures are justified.

In conjunction with any updates to its quantified system risk model, LUL should review and update its safety decision making standard to clarify how the model and other risk assessment processes should be applied in practice (paragraphs 101 and 102).

3 *The intent of this recommendation is that learning from previous accidents should be consistently actioned effectively to help prevent future accidents from occurring.*

LUL should review and improve its management processes for ensuring that appropriate actions are taken in response to the findings and recommendations of its formal investigations (paragraph 101).

Appendices

Appendix A - Glossary of abbreviations and acronyms

CCTV	Closed-circuit television
CRA	Customer Risk Assessment
FIR	Formal Investigation Report
FWI	Fatality and Weighted Injury
LUCC	London Underground Control Centre
LUL	London Underground Limited
LUQRA	London Underground Quantified Risk Assessment
OPO Monitor	One Person Operation Monitor
ORR	Office of Rail and Road
PTI	Platform-Train Interface
RAIB	Rail Accident Investigation Branch
RSSB	The company is registered as ‘Rail Safety and Standards Board’, but trades as ‘RSSB’.

Appendix B - Investigation details

RAIB used the following sources of evidence in this investigation:

- information provided by witnesses
- closed-circuit television (CCTV) recordings taken from the station CCTV system
- site photographs and measurements
- accident reconstruction
- competence records
- documented procedures, standards and risk assessments
- historic incident data
- LUL Formal investigation report - Waterloo Station Bakerloo Line platform 3, Passenger Fatality 26 May 2020
- LUL Formal investigation report - Waterloo Station Bakerloo Line, Passenger Fatality, 27 September 2015
- a review of previous RAIB investigations that had relevance to this accident.

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