RAIB

Rail Accident Investigation Branch

Rail Accident Report

Passenger trapped in a train door and dragged a short distance at Newcastle Central station 5 June 2013

Report 19/2014
September 2014

This investigation was carried out in accordance with:

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

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(Cover image courtesy First TransPennine Express)

Passenger trapped in a train door and dragged a short distance at Newcastle Central station 5 June 2013

Contents

Summary

At 17:02 hrs on Wednesday 5 June 2013, a passenger was dragged by a train departing from platform 10 at Newcastle Central station. Her wrist was trapped by an external door of the train and she was forced to move beside it to avoid being pulled off her feet. The train reached a maximum speed of around 5 mph (8 km/h) and travelled around 20 metres before coming to a stop. The train's brakes were applied either by automatic application following a passenger operating the emergency door release handle, or by the driver responding to an emergency signal from the conductor. The conductor, who was in the rear cab, reported that he responded to someone on the platform shouting at him to stop the train. The passenger suffered severe bruising to her wrist.

This accident occurred because the conductor did not carry out a safety check before signalling to the driver that the train could depart. Platform 10 at Newcastle Central is a curved platform and safe dispatch is particularly reliant upon following the correct dispatch procedure including undertaking the pre-dispatch safety checks.

The investigation found that although the doors complied with the applicable train door standard, they were, in certain circumstances, able to trap a wrist and lock without the door obstruction sensing system detecting it. Once the doors were detected as locked, the train was able to move.

In 2004, although the parties involved in the train's design and its approval for service were aware of this hazard, the risk associated with it was not formally documented or assessed. The train operator undertook a risk assessment in 2010 following reports of passengers becoming trapped. Although they rated the risk as tolerable, the hazard was not recorded in such a way that it could be monitored and reassessed, either on their own fleet or by operators of similar trains.

The RAIB has made six recommendations. One of these is for operators of trains with this door design to assess the risk of injuries and fatalities due to trapping and dragging incidents and take the appropriate action to mitigate the risk.

Two recommendations have been made to the train's manufacturer. One of these is to reduce the risk of trapping on future door designs, and the other to review its design processes with respect to hazard identification and recording.

One recommendation has been made to the operator of the train involved in this particular accident. This is related to the management of hazards associated with the design of its trains and assessment of the risks of its train dispatch operations.

Two recommendations have been made to RSSB. One is to add guidance to the standard on passenger train doors to raise awareness that it may be possible to overcome door obstruction detection even though doors satisfy the tests specified within the standard. The other recommendation is the consideration of additional data which should be recorded within its national safety management information system to provide more complete data relating to the risk of trapping and dragging incidents.

Introduction

Preface

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

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

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

Key definitions

4 All dimensions in this report are given in metric units, except speed which is given in imperial units, in accordance with normal railway practice. Where appropriate the equivalent metric value is also given.

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

The accident

Summary of the accident

6 At 17:02 hrs on Wednesday 5 June 2013, a passenger was unable to remove her wrist when it became trapped in an external door of a train that was about to depart from platform 10 at Newcastle Central station (figure 1). The train started to move and she was forced to move beside it to avoid being pulled off her feet (this type of incident is known in the railway industry as 'trapping and dragging'). The train reached a maximum speed of around 5 mph (8 km/h) and travelled around 20 metres before coming to a stop.

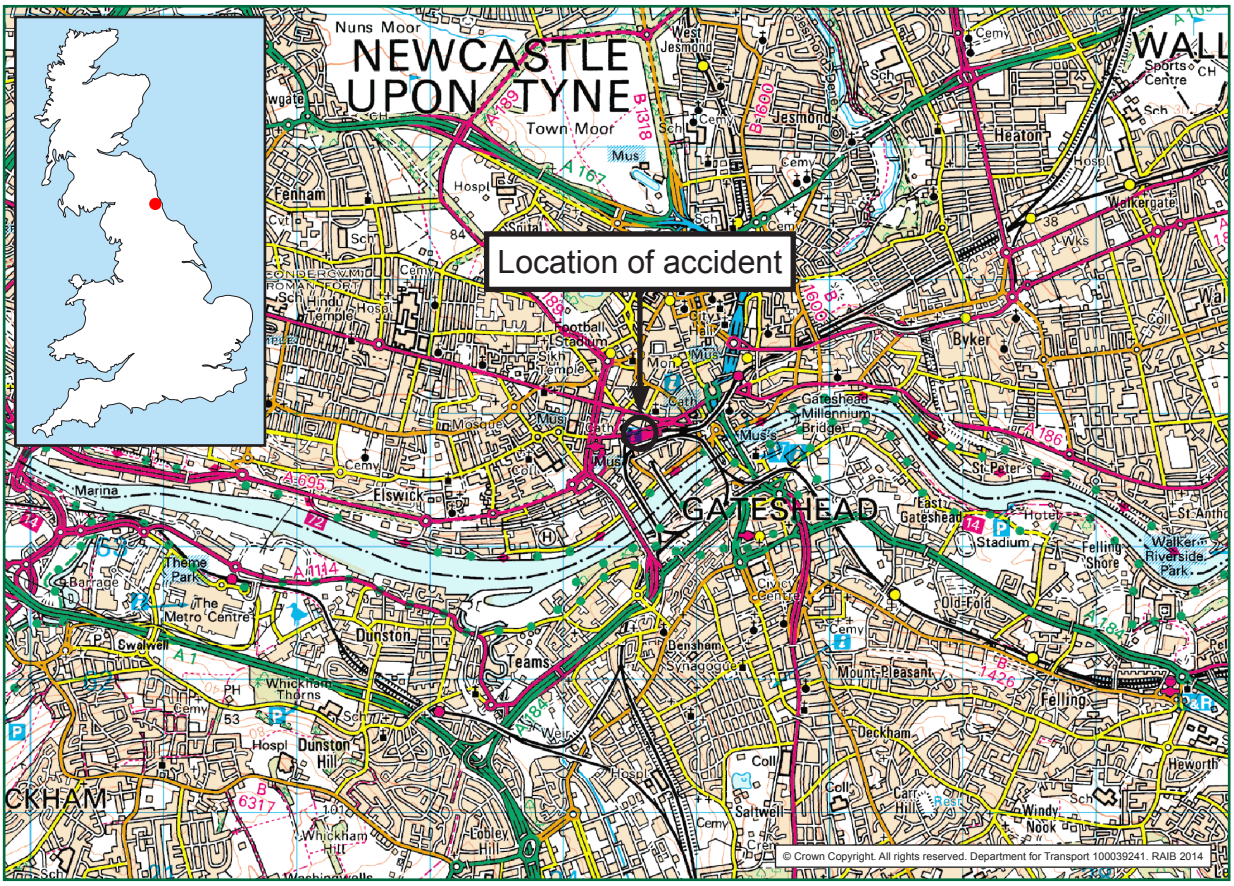

Figure 1: Extract from Ordnance Survey map showing the location of the accident

7 The passenger was able to stay on her feet but suffered soft tissue damage to her wrist and was very shaken. Had the train not stopped when it did, the outcome could have been more serious.

Context

Location

8 Platform 10 is a curved terminal platform, as are the adjacent platforms 9 and 11. It has a radius of curvature of approximately 170 metres. When viewed in the direction of a train departing from platform 10, the curve is towards the left with the platform on the right-hand (convex) side of the train (figure 2).

Figure 2: Class 185 unit standing at platform 10 at Newcastle Central station (Image courtesy of First TransPennine Express)

Organisations involved

9 First TransPennine Express (FTPE) was the operator of the train and the employer of the driver and conductor. It was also the employer of staff involved in the operational control of its train services.

10 Siemens Rail Systems (Siemens) was the designer, manufacturer and maintainer of the Class 185 train involved, which is one of the Desiro UK family of trains.

11 Interfleet Technology Limited (Interfleet VAB) was the *vehicle acceptance body* (VAB) responsible for assessing and issuing approval certificates to confirm the compliance of the Class 185 with the relevant railway standards.

12 The Health & Safety Executive (Her Majesty's Railway Inspectorate (HMRI)) was the body responsible at that time for approving the design of the Class 185 in accordance with the Railways and Other Transport Systems (Approval of Works, Plant and Equipment) Regulations 1994 (the ROTS Regs) prior to it coming into service in 2006. Responsibility for this role was subsequently transferred to the Office of Rail Regulation (ORR) and the ROTS regulations were superseded by the Railways and Other Guided Transport Systems (Safety) Regulations 2006 (the ROGS Regs).

13 All organisations freely co-operated with the investigation.

The train involved

14 Train reporting number 1P59, was the 17:02 hrs service from Newcastle to Manchester Airport and was formed by a three carriage Class 185 *diesel multiple unit* (DMU). All relevant inspection and maintenance activities on the vehicle were up to date.

15 As is normal for this service, the train was full, with passengers standing in the gangways, aisles and vestibule areas.

Class 185 doors and control equipment

16 Each of the three carriages has two double-leaf passenger doors on each side. Each door leaf is fitted with a rubber leading edge. The leading edges meet in the centre of the doorway forming a seal when the door leaves are closed (figure 3). There is an electrical sensing element within each rubber edge designed to detect obstructions when the leaves are closing. This is known as a sensitive door edge. The control of the doors is such that the door will fully reopen if an obstruction is detected. The operation of the doors is explained more fully in paragraph 47.

Figure 3: Class 185 double-leaf external passenger door

Figure 4: Class 185 rear cab door control panel

17 In the cabs of the train are two control panels (one on each side of the train) from which the conductor, when riding in the rear cab, can control the train doors and communicate with the driver (figure 4). The panel has illuminated buttons and indicators which show the status of the train doors. There is a *door key switch* (DKS) on the panel which, when turned to the 'on' position by a key, makes the buttons and indicators active.

18 There is a bodyside indicator lamp on each side of every carriage (figure 5). This illuminates orange if the passenger doors on that particular carriage are not closed and locked, and extinguishes if they are. There are also door control panels in the centre carriage known as the guard's operating panel, or GOP. The bodyside indicator lamp will flash on the carriage where the DKS has been turned on to activate the door control panel.

Figure 5: Class 185 bodyside indicator lamp

Platform equipment involved

Platform equipment assisting train dispatch

19 To assist with train dispatch, platform 10 is fitted with a *train-ready-to-start control*, or TRTS (figure 6). The conductor operates this by pressing a button a few minutes before the departure time. This informs the signaller, or the signalling system if *automatic route setting* is in operation, that the train is ready to depart.

20 If the route ahead is clear, the signaller or signalling system sets the platform starting signal, which is beyond the front of the train, to a proceed aspect (yellow or green) indicating the train may depart (figure 7). At platform 10, the TRTS control is located on a post close to the terminal end of the platform.

21 Approximately two-thirds along the length of the platform from the terminal end, is an *'off' indicator* (figure 7). When illuminated, this informs the conductor that the route ahead is clear for the train to depart. The 'off' indicator is necessary as the conductor cannot easily see the platform starting signal from the rear of the train because of the curvature of the platform.

Staff involved

22 The conductor involved joined FTPE as a qualified conductor in January 2013, having previously worked in that role with National Express East Anglia since February 2011. Following a period of training with FTPE, including familiarisation with the Class 185 unit and learning the details of the routes over which he was to work, he was signed off as a competent conductor by FTPE on 5 April 2013. His training and competence records were up to date at the time of the accident.

Figure 6: Platform 10 TRTS control (Image courtesy of First TransPennine Express)

Figure 7: Platform 10 starting signal and 'off' indicator as seen from the rear of front vehicle

23 The driver of the train has been a driver since 2001 and was a senior driving instructor. His training and competence records were up to date at the time of the accident.

External circumstances

24 The accident occurred in daylight and entirely under the station canopy.

25 There was a train standing at platform 11 adjacent to platform 10 (figure 2). This service had arrived at 16:45 hrs and was due to depart at 17:32 hrs. The RAIB's subsequent observations suggest that it was likely that there were some passengers on the platform waiting to board this other train, although the conductor has stated that the platform was not particularly busy. There was no train at platform 9. There were no external circumstances that contributed to the accident.

The investigation

Sources of evidence

26 The following sources of evidence were used:

- witness evidence;
- closed circuit television (CCTV) recordings from cameras on board the train;
- data from the event log recorded on the local door control unit;
- transcripts of voice communications between parties immediately following the accident;
- site photographs, measurements and observations at Newcastle Central station;
- documents provided by all the organisations involved (paragraph 9);
- minutes of meetings between the RAIB and the organisations involved;
- results from door tests conducted by the RAIB; and
- a review of previous RAIB investigations that had relevance to this accident.

Note: There was no evidence available from the station's CCTV system as the camera that had been looking towards platform 10 had been repositioned as a station security measure.

Key facts and analysis

Sequence of events

Events preceding the accident

27 The conductor signed on for duty at 14:32 hrs in York. His first journey that day was from York to Newcastle, arriving at 16:09 hrs. He took a break before returning to the same train, which formed the 17:02 hrs departure to Manchester Airport.

28 Approximately 15 minutes before the departure time, the conductor and the driver arrived at the rear cab of the train. The driver then went to the front cab and prepared it for departure. Sometime later the conductor went to buy a coffee from the station concourse.

29 Approximately seven minutes prior to departure the passenger doors were released to allow passengers to open the doors and board. The train quickly filled up. Accounts differ as to whether the driver or conductor released the passenger doors.

30 The conductor stated that when he returned to the train he was surprised to find the passenger doors open. He then made an on-train announcement confirming the destination of the train and the stations at which it called.

Events during the accident

31 The conductor stated that two minutes prior to the time of departure, he left the rear cab and operated the TRTS control on the platform. By this point he should have operated the door key switch (DKS) to make the control panel active (paragraph 17). However, he had not done so.

32 The route ahead was clear. Consequently, the automatic route setting set the platform's starter signal to a proceed aspect. The conductor has stated that at this stage he probably observed this signal by looking at it across platform 9, along the left-hand side of his train. This was possible as there was no train in platform 9. (This action was not in accordance with the FTPE dispatch procedure and is discussed further in paragraph 93).

33 The conductor stated that closer to the time of departure he walked over to platform 11 (so he could see down the full length of the train in the curved platform 10) and checked that it was safe to close the passenger doors. He stated that he sighted the 'off' indicator on platform 10. He then walked back to the rear cab and pressed the button to close the passenger doors. Pressing the doors close button had no effect because he had not turned the DKS on, and he did not notice that the control panel was unlit.

34 The conductor stated that he again walked over to platform 11 to check that the doors had closed and they were clear of passengers. He recalled that he thought the doors were closed, but he could not recall checking the status of the bodyside indicator lamps which indicate whether the doors are closed and locked. He stated that he then returned to the rear cab, boarded the train and closed the cab door. At this stage he realised that the DKS was off. He turned it on and the buttons and indicators on the panel illuminated. He then pressed the button to close the passenger doors. This action closed three passenger doors that were still open. The other doors had 'auto-closed'[1] and were already closed but not locked (paragraph 86).

35 While he was in the rear cab with the cab door closed, two people ran past and headed for the first open door, which was the rear door of the centre carriage. The conductor stated that he did not see them. The timing of events indicates that at this time he was probably occupied with the door control panel. One of the two people was slightly ahead of the other and she managed to board as the doors began to close. The other tried to board when the doors were not quite fully closed. Her right forearm made contact with the leading edge of the right-hand door leaf and the pair of leaves met, trapping her right wrist between them. This was not detected by the sensitive door edges (paragraph 16) so the leaves did not reopen, but locked in the closed position. The train door control system detected all the doors to be closed and locked.

36 Once closed and locked, the 'doors locked' indicator illuminated on the conductor's panel. On seeing this, he instructed the driver to depart, using the communication buzzer. The train began to move around 8 seconds after the doors had closed. The train reached an estimated maximum speed of 5 mph (8 km/h) and travelled an estimated distance of 20 metres. The train moved for approximately 8 seconds during which the trapped passenger had to move along the platform to stay on her feet.

37 It was not possible to accurately determine the distance moved or the maximum speed reached during the accident because there was no data available from the *on-train data recorder*. This had been overwritten by more recent data because of the time that had elapsed between the accident and it being reported (paragraph 125). Similarly it was not possible to determine the means by which the train brakes were applied. It is known that one of the passengers in the vestibule area close to the trapped passenger operated the emergency door release, which would have activated the emergency brake.

38 The conductor stated that he had the rear cab window open and that he heard someone on the platform shouting 'stop'. He then sent the 'stop' message to the driver using the communication buzzer and also pressed the emergency stop plunger in the rear cab. On hearing the 'stop' message from the conductor the driver applied the train brake. The driver reported that a passenger communication device was also operated, but that no one spoke to him.

[1] On a Class 185 the 'auto-close' feature automatically closes a pair of doors after 60 seconds if no passengers have passed through the doorway during this time. This occurs even when there is no door control panel active. The doors remain unlocked and can be reopened by pressing either the interior or exterior door open buttons.

Events following the accident

39 Once the train had stopped, the conductor checked that it was still fully in the platform before releasing the passenger doors. He then met the passenger who had been trapped on the platform. He escorted her to the rear carriage where she was looked after by a passenger she knew. The conductor and the driver briefly met on the platform. The driver then spoke to the signaller before assisting the conductor with resetting the passenger communication device and the emergency door release that had been operated.

40 The train departed 11 minutes late. The conductor wrote down the injured passenger's name and address before she alighted, as intended, approximately 15 minutes later at Durham. The injured party reported that her wrist was very painful and swollen and the following day she had it x-rayed. She had sustained soft tissue damage with no fractures.

41 First TransPennine Express became aware of the accident, but not its full details, because one of the passengers on the train sent a customer complaint to the First Group customer relations centre on 6 or 7 June. The RAIB were informed of this accident on 3 July 2013 by FTPE. The reasons for the delay in reporting are discussed in the observations section of the report (paragraph 125).

Background information

First TransPennine Express dispatch procedure for platform 10

42 When dispatching a train from platform 10 at Newcastle, FTPE specified that its staff should use a method known as self-dispatch. The Railway Rule Book[2], published by RSSB[3], defines this as 'guard dispatch from an unstaffed platform'. This involves the train's guard, or conductor, informing the driver when to depart, following completion of the conductor's safety checks.

43 A key task for conductors, in which they should be trained, is to ensure that it is safe for their train to depart. This is defined in the Railway Rule Book as 'the train safety check'. This check is intended to ensure that the doors are properly closed and that nothing is trapped in the doors.

44 Figure 8 illustrates FTPE's expected method for conductors dispatching a Class 185 from the rear cab at platform 10 at Newcastle Central. The steps are:

a. With the rear cab door open, operate the door key switch (DKS) on the door control panel to the 'on' position.

b. Approximately two minutes prior to departure time, operate the platform's TRTS button (paragraph 19).

c. The conductor should then check that the platform 'off' indicator is illuminated. To be able to see this, it is necessary for the conductor to move to the position indicated by **A**.

[2] Rule book GE/RT8000, module SS1, issue 3, March 2013, station duties and train dispatch, section 3.6.

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

d. Approximately one minute prior to departure, the conductor should move to a position where all of the train doors are visible prior to closing them. To be able to see this on platform 10, it is necessary for the conductor to move to the position indicated by **B**.

e. If safe to do so, ie there are no passengers near to the train, or still boarding, the conductor moves back to the rear cab and operates the 'close passenger doors' button on the door control panel.

f. The conductor should move again to the position where all the doors are visible (position **B**), checking that they are closed and unobstructed and the side of the train is clear, ie the train safety check.

g. The conductor should also check the bodyside indicator lamps. When the doors are closed the lamps will be extinguished, except for the one on the rear carriage where the DKS has been turned on and the cab door is open; this will be flashing.

h. The conductor can then enter the rear cab and close the cab door. Once all the doors are detected closed and locked, a blue indicator on the door control panel illuminates to confirm this and a safety circuit allows the train to be moved. The conductor can then instruct the driver to depart by pressing the communication buzzer twice. The conductor should remain at the door controls until the train has fully cleared the platform.

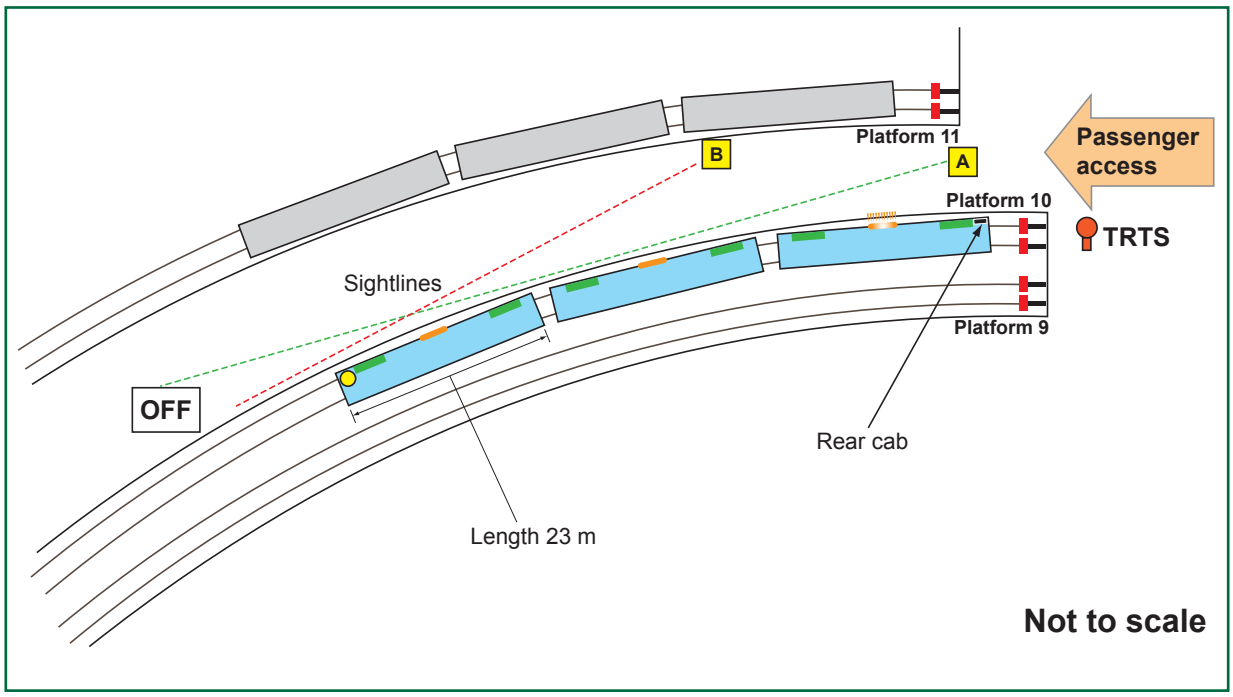

Figure 8: First TransPennine Express model dispatch procedure for self-dispatch from platform 10 from the rear cab

Applicable standard for passenger doors

45 The *Railway Group Standard* for passenger doors applicable to the Class 185 when it was approved was GM/RT2473, issue 1, dated February 2003 'Power Operated External Doors on Passenger Carrying Rail Vehicles'.

46 Of particular relevance are the two specified obstruction tests:

a. on closing on a rectangular bar with a cross-section of 30 mm by 60 mm (with the longer edge vertical), the door forces should be reduced, or the doors shall reopen, or if it becomes trapped, it should be capable of being removed with a maximum force of 150 N; and

b. if a smooth rectangular bar with a cross-section of 10 mm by 50 mm is trapped (with the longer edge vertical) it should be capable of being removed with a maximum force of 150 N.

These test pieces are intended to be broadly representative of a wrist and an open hand respectively. The dimensions of these test pieces and their method of use are the same as that specified in the new European standard, FprEN 14752[4], which was being drafted at the same time as GM/RT2473.

Class 185 passenger doors

47 Siemens Desiro UK vehicles in service prior to 2004 had pneumatic passenger door sensitive edges[5]. Siemens worked with a train door supplier and developed a sensitive door edge with a sensor that was electrically operated. This allowed the detection of smaller obstructions and continuous monitoring of the door's performance. At that time this was to be used on the Desiro UK Class 350/1 and 360/2 fleets (used by London Midland and Heathrow Express respectively) as well as the FTPE fleet of Class 185s.

48 The electrical detection sensor in each door leaf runs from the top to the bottom of the door and is housed within the leaf's leading rubber edge (figure 9). The rubber edge of one of the door leaves is a 'male' edge and the other a 'female' edge. A feature of this design is that it is necessary to switch off the detection of the female sensitive edge shortly before the two leaves meet to prevent it sensing the opposite door leaf when they touch (which would cause the door to reopen). The male sensitive edge remains active until the door is detected to be closed and locked.

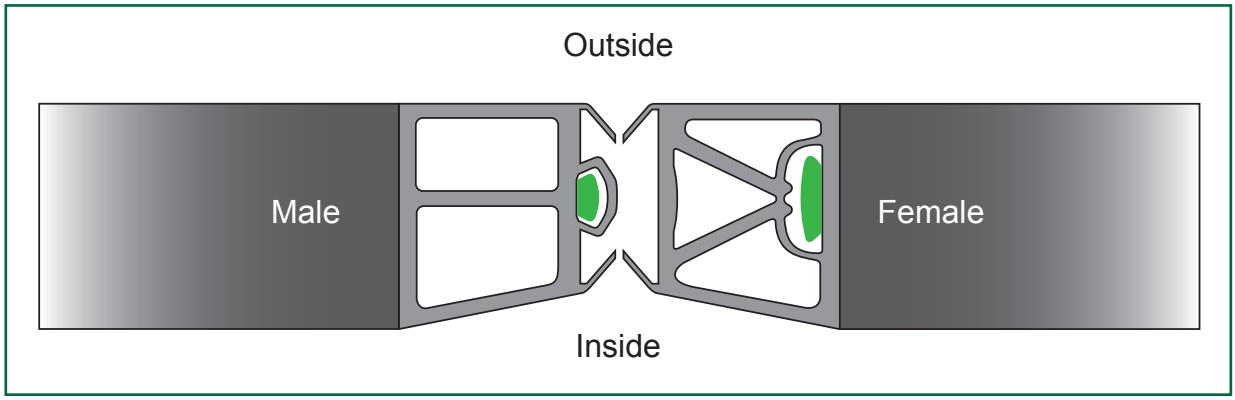

Figure 9: Cross–section through the sensitive door edges, showing the rubber sealing edge profiles housing the electrical sensing elements (shown in green)

[4] This is the final draft of the European Standard EN14752. See https://www.cen.eu.

[5] Pneumatic sensitive door edge detection consists of a sealed tube within the door edge. Contact with the edge results in a change of pressure within the tube. This change is detected by a pressure sensor and allows the door to reopen via the door control system.

49 During testing by the RAIB it was noted that the sensitive edges were capable of detecting the smaller of the two test pieces, normally only used for the obstacle extraction test (paragraph 46b). When tested with this 10 mm thick test piece both door leaves fully opened and then re-closed. If the obstruction was left in the door, the cycle repeated.

50 Siemens had developed a door obstruction detection test for use in routine inspection and maintenance activities. This involved using the larger of the two test pieces defined in the standard (paragraph 46a). A successful test resulted in the leaves fully reopening when contact was made with the test piece (deemed to be broadly equivalent to a wrist). There was a further test involving pressing the door edges in turn to activate each sensitive edge as the leaves were closing, to individually verify the function of each. Again, correct operation was confirmed if they fully reopened.

Post-accident door tests

51 On 30 June 2013, having become aware of the accident, Siemens and FTPE tested the door involved in the accident. The door passed both tests described in the Siemens test procedure.

52 On 10 July 2013 the RAIB conducted tests on the same door and other doors on the same unit. When both the standard 30 mm by 60 mm test piece, and another test object, measuring 34 mm by 54 mm (the size of which was based upon the wrist size estimated by the trapped passenger) was placed at a right-angle to the closing door leaves, they reopened as designed.

Figure 10: Adult male wrist (approximately 45 mm by 70 mm) trapped in a door detected as closed and locked

53 Siemens depot staff were then able to demonstrate to the RAIB how a correctly functioning door that met the design and maintenance test criteria could, nevertheless, trap an adult wrist and indicate to the train control system that the leaves were closed and locked (figure 10). This could be done by deflecting the male rubber edge inwards or outwards, ie away from the female rubber edge. This caused the male edge's sensing element to be moved away from the direction of the movement of the closing leaf and not detect the obstruction. By the time the leaves came together, the female sensitive edge had been switched off (paragraph 48). In this way it was possible, but not always easy, to trap the test pieces and also a reasonably large adult male wrist (figure 11).

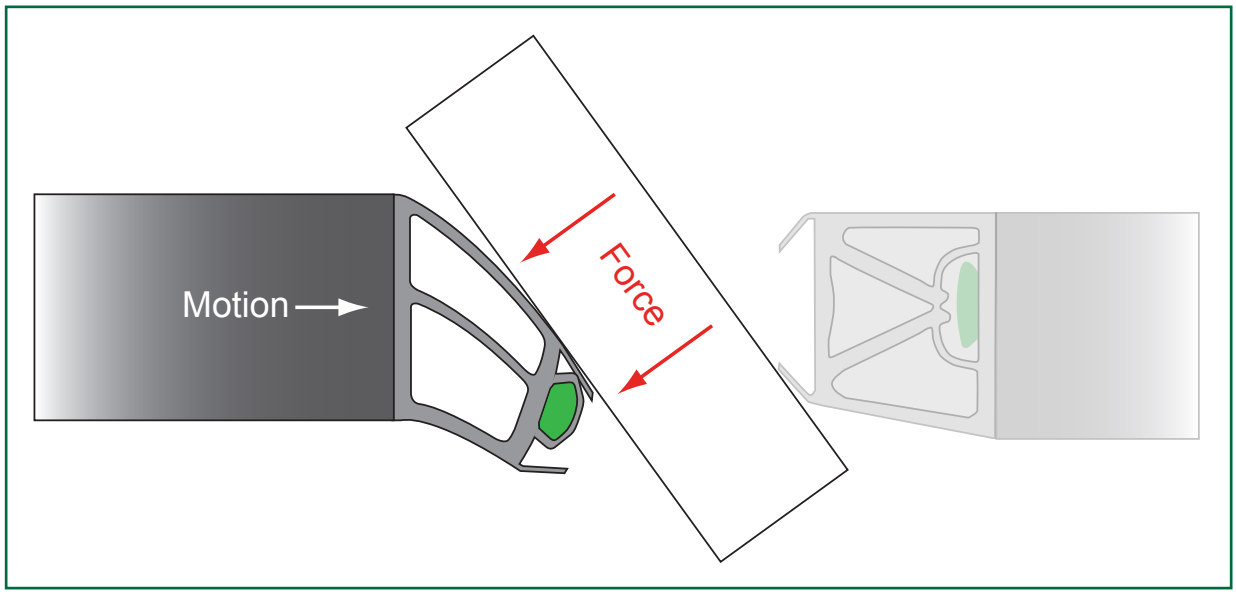

Figure 11: Cross –section through the sensitive door edges, showing the rubber sealing edge profiles and the deflected male edge

54 With a stationary train, removal of a trapped wrist in these circumstances is possible but not easy. Following the Newcastle accident, FTPE undertook a risk assessment (paragraphs 104 to 110) within which it was recorded that a member of FTPE staff recreating the trapping of his wrist, reported that it was painful and difficult to remove. The view was also expressed that a trapped test piece (the size of which was not recorded) was difficult to remove, requiring a 'foot braced against the door' to achieve.

The approval process for the Class 185

55 Before the Class 185 was permitted to operate, it required approval from HMRI. At that time HMRI was part of the Health and Safety Executive. The approval process was undertaken in accordance with the ROTS Regs (paragraph 12). HMRI's approval process involved a review of documents relating to the train's design and its testing, including the operation of the train doors.

56 New rail vehicles entering service on the national railway network also required 'engineering acceptance'. Railway Group Standard GM/RT2000 issue 2, dated October 2000 'Engineering acceptance of rail vehicles' applied to the Class 185 at the time it was being approved. Interfleet (VAB) was appointed as the vehicle acceptance body (VAB) responsible for the engineering acceptance of the Class 185. Its role was to assess the compliance of the vehicle against the requirements within relevant standards and issue approval certificates. Such standards included the Railway Group Standard applicable to passenger doors (paragraph 45). It had performed this role on earlier classes of Desiro UK units, including the Class 350 which had the same design of sensitive door edge as the Class 185.

57 The Engineering Acceptance Manager at Interfleet (VAB) had experience of testing passenger doors. He was familiar with the passenger door standard GO/OTS300, which preceded that current at the time of approval of the Desiro trains (paragraph 45). This earlier standard prescribed two tests. The first was that the doors should reopen, or there should be a reduction in the closing force, when they closed upon an obstruction 25 mm wide. Trapping of an obstruction smaller than this was allowed, but it should be capable of being 'easily withdrawn'. Unlike the then current standard, no maximum withdrawal force was specified in GO/OTS300.

58 In October 2004, during an inspection of a Desiro Class 350 door fitted with electrically operated sensitive door edges, he applied a practical assessment of the ease of trapping and/or removal of an obstruction by introducing his own hand between the closing door leaves. He found that his hand could be trapped in many of the doors tested. He noted that all of the leaves could fail to sense the presence of his hand if it was not held at 90 degrees to the direction of door leaf travel. He also reported that the rubber door edges were softer and more pliable than those previously used by Siemens on pneumatic sensitive door edges, and he judged that the rubber had a higher coefficient of friction. He noted that it was not easy to remove his trapped hand.

59 However, the Class 350 doors passed the obstruction test prescribed in the current passenger doors standard (GM/RT2473). For this reason Interfleet (VAB) felt that it could not withhold the engineering acceptance certificate. However, the Engineering Acceptance Manager documented his findings and raised his concerns with Siemens and HMRI.

60 In its documented response, Siemens highlighted to HMRI other safety features such as the door closing audible warning (known as a hustle alarm) and infrared passenger sensors incorporated within the door system. It stated that the latter would assist in the detection of a trapped person (albeit only if they were trapped on the inside of the train). Siemens believed that the increased pliability of the rubber would lead to less passenger injury caused by contact with a door edge, and that this feature also assisted in withdrawing a trapped limb. Furthermore the documentation stated that platform staff and/or train crew checks would be undertaken prior to dispatching a train (in accordance with the rule book). The documentation also records that Siemens engineers estimated that trapping might occur in 1 to 2% of cases where contact is made with the sensitive edge, although the RAIB has not been able to see any analysis to support this.

61 The Engineering Acceptance Manager's response to Siemens and HMRI was that, while he accepted that the edges would cause less injury if they made contact with a passenger, he believed that their pliability and friction properties made it more difficult to remove a trapped hand, as compared to the earlier designs of door edges.

62 In November 2004, HMRI and Siemens visited the door manufacturer to review the operation of the proposed passenger doors for the Class 185 (the door edge features being the same as those on the Class 350). The minutes from that meeting record that HMRI's inspector was able to prevent the door edges from detecting his hand prior to locking by deflecting the male door edge in the manner recreated in the RAIB tests (paragraph 53). Witness evidence indicates that he was then able to withdraw his hand. The minutes also show a photograph of a wrist between closed door leaves deflecting the rubber edges.

63 The minutes from that visit state that HMRI's inspector was 'satisfied with the electrical sensing edge design'. The minutes record that this was in consideration of the other safety features present on the doors and the processes associated with train dispatch. The inspector has since stated that given the circumstances (the trains were already largely built, or in production) it was decided not to require the retrofit of an alternative system. The inspector has also stated that it was made clear to manufacturers that further vehicles with this design of door edge equipment would not be acceptable, although the RAIB has found no documented evidence of this.

64 In December 2005, HMRI recorded that the electrically sensitive door edges were deemed acceptable.

65 In March 2006, HMRI gave approval for trial operations of the Class 185 and full approval was given in August 2006.

Reports of other relevant door trapping incidents

66 First TransPennine Express has provided the RAIB with reports relating to three separate allegations of trappings in Class 185 passenger doors, dated December 2009, March 2010 and May 2010. It is not clear from the reports whether the December 2009 and May 2010 incidents resulted in actual trappings, rather than incidents of the passengers being contacted by the closing door leaves, which then automatically reopened. However, the report relating to the March 2010 incident states that the person was 'trapped and doors had to be released'. FTPE has since told the RAIB that the person complained of having a trapped wrist and was inside the train. Based upon the statement that the doors had to be released, this incident is likely to have involved the doors having been closed and locked (ie a door trapping).

67 Following each incident, the doors were tested by the Siemens maintenance team using their inspection procedure (paragraph 50) and the results reviewed by the FTPE fleet team. The doors passed the tests on all three occasions.

68 After the May 2010 incident, FTPE recorded a video of how a wrist could become trapped in the closing passenger doors, from the inside, by deflecting the male door edge. This was achieved on a selection of doors on two 185 units not involved in the reported trapping incidents.

69 First TransPennine Express, together with Siemens, undertook a risk assessment in response to the three reports and the recorded demonstration of wrist trapping. One of the hazards considered was a fatality from trapping and dragging a passenger. This is discussed further in paragraph 104.

70 In September 2011, a conductor of a Class 185 unit departing from Durham station submitted an incident report which described how a passenger's wrist had become trapped in the closing doors while outside the train. The conductor noted that the doors had closed and the bodyside indicator lamps had extinguished. He observed the trapped person and reopened the doors. The doors were tested against the inspection procedure and it was reported that they were operating correctly. This report was then signed off by FTPE, the company having decided that there was no further action to be taken.

71 On 18 January 2012, Siemens Rail Systems, also responsible for the maintenance of London Midland's Class 350 fleet, tested a set of Class 350 doors following a report of a person trapped by the arm. It was noted that the door interlock had been made, the bodyside indicator lamps had extinguished and the vehicle moved approximately 1.2 metres during an uncoupling movement. There were no faults found with the doors, but the means by which the detection of sensitive door edges could be defeated by deflecting the male door edge was described in the report. It was suspected that the passenger was attempting to open a pair of doors that were already closed.

72 London Midland records from January 2008 to April 2014 show that there was a trapping and dragging incident on a Class 350 on 15 May 2009 at Wembley Central station. During this incident, the passenger on the platform managed to pull her hand free. There are no further details available of these incidents. London Midland has informed the RAIB that following both it conducted investigations and that there were no changes, either recommended or made, to the doors' operation or its dispatch procedures.

73 On 25 October 2013, following the Newcastle accident, there was a report of a person having their arm trapped in the door of a FTPE Class 185 at Leeds station. The person was inside the train and was passing some dropped papers to somebody who was on the platform. The platform dispatcher noticed the person's trapped hand and told the conductor to reopen the doors. The door was tested on 28 October 2013 by Siemens and FTPE Fleet and it was recorded as working correctly.

74 Other reported door trapping incidents involving operators of Desiro trains fitted with electrically operated sensitive door edges are discussed in paragraph 151.

Identification of the immediate cause[6]

75 The train moved with the passenger's wrist trapped in the closed door.

Identification of causal factors[7]

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

- the passenger attempted to board the train as the door was closing (paragraph 35);
- a characteristic of the Class 185 door design is that it allowed a wrist to become trapped and not detected (paragraph 53); and
- the conductor did not see the passenger trapped in the door because he did not do a final safety check before dispatching the train (paragraph 36).

The actions of the passenger

77 The passenger attempted to board the train as the door was closing.

78 The passenger was in a rush and wanted to catch the train. She has told the RAIB that she expected the train doors to reopen like a lift door if they detected an obstruction.

79 As the passenger attempted to board, the doors were closing and her right arm was in the doorway.

80 Her arm became trapped and she tried to free it from the doors. She found this difficult to do. This may have been because:

a. She was holding a mobile phone in her right hand.

b. There was resistance to her withdrawing her hand, because the deflected rubber edges were pressing inwards on the base of her hand, which is thicker than her wrist.

c. Once the train was moving, her arm would have been bending at the wrist as she had to move along the platform with it.

The Class 185 passenger doors

81 The Class 185 doors allowed the passenger's wrist to become trapped and not detected, thereby allowing the train to move.

82 The manner in which a wrist can be trapped and not detected is explained in paragraph 53.

83 The design, approval and management issues that led to this are covered in paragraphs 97 to 102.

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

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

The conductor's dispatch

84 **The conductor did not see the passenger trapped in the doors because he did not do a final safety check before dispatching the train.**

85 The dispatch process carried out by the conductor was not in accordance with the rule book, FTPE procedures, or the way he had been trained. At the start of the dispatch he had not turned on the door key switch (DKS) to energise the door control panel he was using, and did not realise this until late in the dispatch sequence. He had not noticed that the door control panel was not illuminated when he first attempted to close the passenger doors. He did not observe the state of the bodyside indicator lamp on the rear carriage that would have indicated to him that the DKS was off (paragraph 18).

86 RAIB's analysis of the on-board CCTV recordings indicates that once he had turned the DKS on, the conductor's action of pressing the 'close doors' button closed three passenger doors which had not already closed automatically by 'auto-closing' (figure 12). One was the rear door of the front carriage and the other two were the front and rear doors of the centre carriage. The door at the front of the centre carriage had been open for over 2 minutes before the conductor closed it. The door at the front carriage and the rear door of the centre carriage (which trapped the passenger) had both been open since they were first opened more than 7 minutes earlier.

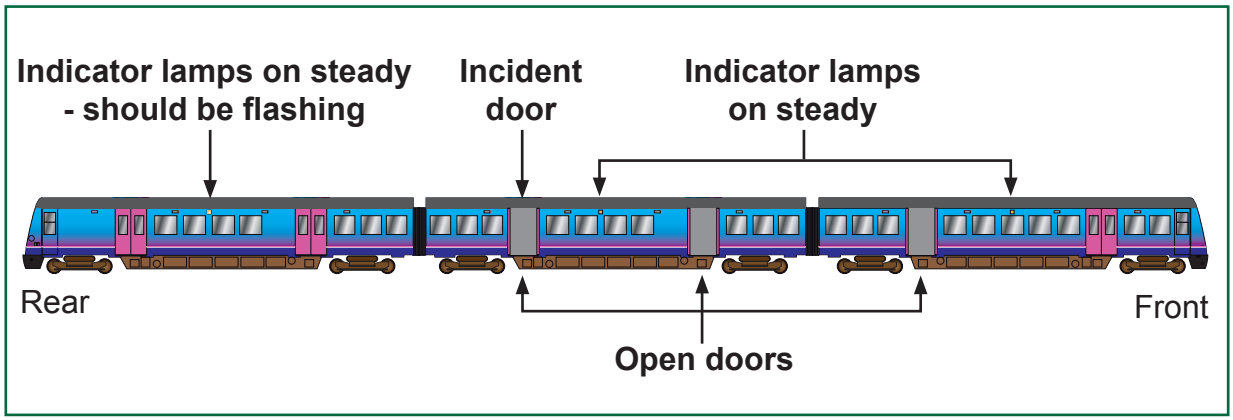

Figure 12: Condition of passenger doors and bodyside indicator lamps at the time the conductor reported that he was undertaking the train safety check

87 The conductor's training records show that he had been trained to stop and restart the dispatch process if it became interrupted at any stage. Once he was in the rear cab, with the cab door closed, and having realised that the DKS was off, he should have restarted the dispatch process from the beginning.

88 The conductor stated that he was unable to explain why he did not undertake a train safety check after closing the passenger doors, or restart the dispatch process. The RAIB believes that there are two possible explanations for this, either:

a. He made an error due to confusion at being ready to depart and then realising that he had not turned the DKS on. He then relied on the door interlock indicator to confirm to him that the passenger doors were closed, locked and clear of passengers, or

b. He consciously ignored what he had been trained to do (possibly with reliance on the illuminated door interlock indicator) to avoid having to restart the dispatch sequence.

89 Had he correctly restarted the dispatch process, or undertaken a subsequent train safety check, he would have almost certainly seen the trapped passenger.

90 The RAIB has examined the conductor's training and assessment records from his current and previous employers. The records include reports of his performance dispatching trains from regular monitored observations. His last assessment prior to the accident was on 10 May 2013, and it recorded that he correctly followed the dispatch process. There is evidence in his training records, from both employers, that shows he was aware of the importance of the train safety check, and that the dispatch process should be restarted from the beginning should it become disrupted.

91 Wednesday 5 June was the conductor's eighth consecutive day working an afternoon shift since returning from five days' leave. He had dispatched this service from Newcastle platform 10 the previous Monday, Saturday and Friday. He had also dispatched a different service from platform 10 on the Sunday preceding the accident. His work at platform 10 over the preceding week indicates that he was familiar with the location.

92 The conductor reported that he did not feel tired at the time of the accident. The Fatigue and Risk Index[8] (FRI) model, which is widely used within the railway industry, indicates that at the time of the accident his previous work pattern had not generated a significant risk of fatigue. The conductor also stated that he did not feel under any time pressure to rush the dispatch. He could not recall having any distractions during the dispatch.

93 When the conductor's knowledge of the routes over which he was to work was assessed by FTPE he correctly identified that there was a risk of misreading the platform starting signals on all platforms at Newcastle[9]. His action of observing the signal across the left-hand side of the train (paragraph 32), although not causal to the accident, is a possible indication of him short-cutting the dispatch process. Observing that the signal is green obviates the need to move away from the rear of the train to see the 'off' indicator on platform 10.

[8] Fatigue and Risk Index available at: www.hse.gov.uk/research/rrhtm/rr446.htm.

[9] Although not documented, FTPE regard it as poor practice to sight the platform starting signal across platform 9 as there is a possibility of mistakenly reading a signal for one of the other platforms.

94 The method of train dispatch from platform 10 at Newcastle is relatively demanding compared to a dispatch from a straight platform. The curvature of the platform requires the conductor to walk twice from the rear cab to a position where the whole train can be seen. Platform observations indicate that moving from the rear cab to this position and back again takes approximately 25 to 30 seconds, and that the whole train is not visible when closing the passenger doors. Therefore safe dispatch is particularly reliant on undertaking a thorough final check.

95 It is possible that the time taken, and the distance that has to be walked during the dispatch process at this platform are factors that increase the likelihood that conductors might choose to rely on the door interlock indication, rather than carry out a final safety check. As is indicated at paragraph 88, it is considered possible that the conductor's reliance on the door interlock (rather than the final safety check) was a factor in the accident (Learning point 1, paragraph 162).

Identification of underlying factors[10]

96 **Although Siemens, FTPE and HMRI were aware of the possibility of a trapping and dragging accident as a result of the undesirable characteristic of the original door design, it was not considered necessary to modify the design, or to put other mitigations in place**.

The original door design

97 The Railway Group Standard for passenger doors (paragraph 45) states that the intent of obstacle detection is 'to minimise the risk and extent of injury' and 'all external passenger doors shall be designed to prevent obstacles being trapped in the door.' It states that the obstruction tests specified (paragraph 46) are a minimum requirement.

98 Before the Class 185 was put into service, Siemens and HMRI were aware of the possibility of a trapping and dragging incident, because of the characteristic that had been highlighted by the Interfleet (VAB) Engineering Acceptance Manager (paragraph 58).

99 It is a requirement of the Health and Safety at Work Act 1974 (and associated legislation), that operators introducing new vehicles into service, should undertake assessments of risk. At that time (2005), guidance on how this should be approached was given by the RSSB document 'Principles of Engineering Safety Management', Issue 3, 2000 (known as the Yellow Book[11]). This advised that safety hazards should be identified and recorded, and that hazards can be identified at any stage during the life of a vehicle, including during its design, testing, approval, operation and maintenance. It also states that hazards should be formally risk assessed and the reasonable practicability of potential mitigation measures assessed. Those hazards which remain should be monitored throughout the life of the vehicle.

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

[11] Withdrawn document section of RSSB's website: www.rgsonline.co.uk.

100 Siemens undertook two risk assessments to support the safety approval of the Class 185. These were completed and signed off by Siemens in January and September 2005. Both of these considered the risk of a fatality from trapping a passenger outside the train. The earlier assessment considered the likelihood of this risk the due to the failure of components within the door system. The other assessment assigned an estimated value to the frequency of a fatality from a trap and drag on a Class 185 vehicle based upon historical data. Neither assessment recorded the specific hazard, nor assessed the resulting risk of trapping by the then known undesirable characteristic of the sensitive edge.

101 First TransPennine Express has told the RAIB that its staff involved in the introduction of the Class 185 were also aware of this characteristic as they had seen the minutes of the meeting between Siemens and HMRI (paragraph 62). However, there is no evidence that this particular hazard was formally recorded in any Siemens or FTPE documents or systems so that it could be monitored and managed during service. Siemens and FTPE have told the RAIB that at that time they thought that any risk was low because:

a. the doors passed the Railway Group Standard tests;

b. HMRI had deemed the door system to be acceptable; and

c. there was a rule book requirement that required a final safety check by those responsible for train dispatch, and this would detect a passenger trapped outside the train.

Approval by HMRI

102 Following the demonstration of how the detection of the electric sensitive door edges could be overcome, HMRI deemed the door system to be acceptable.

103 The RAIB has been shown no documented evidence to explain why HMRI believed that the risk from this specific hazard was acceptable (paragraph 63). There is also no documented evidence that HMRI requested either Siemens or FTPE to specifically assess the risk from this hazard. However, the ORR has informed the RAIB that because they keep records for a limited period in accordance with Government retention policies, they do not know why these decisions were taken by HMRI.

Subsequent service experience

104 In 2010, following the three reports of door trapping incidents and the video evidence of how the sensitive edge detection could be overcome (paragraph 68), FTPE undertook a quantitative risk assessment[12] with technical assistance from Siemens.

105 First TransPennine Express calculated that the frequency of a fatality due to a passenger becoming trapped on the outside of the train was around 1 in 26,600 years across the 51 units of the Class 185 fleet. Following the Newcastle Central accident, FTPE has reassessed this risk and has calculated the frequency of this event as 1 in 16 years.

[12] A numerical risk assessment method which considers the likelihood of an undesirable event occurring and its possible consequences.

106 The large difference between these two frequencies is primarily due to the differences in the assessed likelihood of a trapped passenger on the platform not being able to remove their arm if trapped in the door. The earlier risk assessment estimated this as 1 in 100. The most recent assessment assumes that the person cannot remove their arm. Additionally, the earlier assessment estimated that the likelihood of a trapped passenger being seen before the train moved (thus preventing an accident) was ten times greater than that estimated by the more recent assessment.

107 The RAIB believes that the most recent assessment adopts a more appropriate basis for the estimation of the risk. This is because it assumes (in the absence of trial or test data) that a trapped passenger is not able to remove their arm once the train is moving.

108 As a result of the 2010 assessment, the risk of a fatality from this hazard was ranked as tolerable against the assessment categorisation. This meant that the risk was acceptable if the costs of implementing control measures grossly outweighed the benefits, thus demonstrating compliance with the UK principle[13] of controlling risk so far as is reasonably practicable (SFAIRP).

109 However, there is no evidence that any additional control measures were considered, either engineering or operational, to demonstrate that the risk was controlled so far as is reasonably practicable. First TransPennine Express has told the RAIB that although the means of overcoming the sensitive edge detection was known about by the team responsible for its train fleet, it was not communicated beyond the team such that the management of the risk by operational controls, or other means, could be considered.

110 Because this hazard was not recorded within any FTPE risk monitoring system (such as a hazard log) no monitoring of door incidents and subsequent detailed investigation was carried out. Had this hazard been recorded it is likely that the investigation of the incident at Durham station (paragraph 70) would have revealed that the trapping was associated with the undesirable characteristic of the doors.

Observations[14]

Dispatch risk assessment

111 It is a legal requirement under the Health and Safety at Work Act 1974, that train operators assess the risk of their operations.

112 Between April 2004 and December 2007 issue 1 of Railway Group Standard GO/RT3475, 'Operational Requirements for the Dispatching of Trains from Platforms', required train operators to undertake dispatch risk assessments, and to review these every 3 years.

[13] HSE principles: www.hse.gov.uk/risk/theory/alarpglance.htm.

[14] An element discovered as part of the investigation that did not have a direct or indirect effect on the outcome of the accident but does deserve scrutiny.

113 This standard was withdrawn by RSSB[15] in December 2007 because it was considered to be outside the scope of Railway Group Standards[16].

114 In June 2011 RSSB issued a voluntary standard, RIS-3703-TOM, 'Rail Industry Standard for Passenger Train Dispatch and Platform Safety Measures'. This was issued at the request of the railway industry and offered guidance to station owners and train operators in developing their own station risk assessments. This standard was intended to capture the good practice that was within the withdrawn Railway Group Standard.

115 First TransPennine Express has provided no evidence to show that at the time of the accident it had properly assessed the risks of dispatching from platform 10 at Newcastle Central station, since starting operations there in 2004. However, at about the time that RIS-3703-TOM was issued, FTPE began a project to look at the safety and operational issues associated with its dispatch operations. As part of this initiative, a document was produced by the local service management team that was applicable to dispatch operations at Newcastle. It was entitled 'route risk assessment' and it contained information about station facilities and also highlighted some particular hazards. However, it did not assess the risk from these hazards. This document was never formally issued by FTPE, but it was available to conductors at a local level. It recommended a different method of dispatch to that used at the time of the accident. This is discussed in paragraph 120. This project was not completed before there was a management change within FTPE's operations and safety departments in late 2011.

116 In 2012 following the change of management, FTPE began to undertake risk assessments using the guidance in RIS-3703-TOM, starting with stations for which it was the infrastructure manager[17]. In December 2012 it began to contact the managers of stations at which FTPE operated train services, but at which it was not the infrastructure manager, to arrange to undertake joint risk assessments. (The industry standard suggested that train operators and infrastructure managers should work together on risk assessments, although it reminded both of their own obligations under health and safety legislation).

117 The infrastructure manager of Newcastle Central station is East Coast (a subsidiary of Directly Operated Railways). It is also a train operator and provides platform staff to assist conductors with the dispatch of its own and other operators' trains. East Coast had updated a risk assessment for Newcastle Central in September 2012 which included a procedure for its staff assisting with train dispatch from platform 10. It did not mention dispatch operations of train operators who used self-dispatch from its platforms, such as FTPE.

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[15] RSSB is responsible for managing Railway Group Standards and issuing guidance.

[16] Further details can be found at: www.rssb.co.uk/Library/standards-and-the-rail-industry/2013-leaflet-railway-group-standards.pdf.

[17] Infrastructure manager is identified by the ROGS Regs as the body responsible for managing and operating a station. See http://orr.gov.uk/data/assets/pdffile/0018/2547/rogs2006consolidatedwithamendments.pdf.

118 At the time of the accident, FTPE had a list of those stations from which it operated but for which it was not the infrastructure manager (in this case it was known as a railway undertaking). This list was ordered by the frequency of FTPE services and the volume of passengers carried. Because FTPE only ran an hourly service from Newcastle Central, this station was towards the bottom of the list. There was no weighting given to the risks that were present due to the station facilities and layout, eg platform curvature and a large platform gap; these factors can lead to a higher level of risk to passengers. At the time of the accident, although FTPE had made requests for joint risk assessments with other infrastructure managers of stations at which its trains stopped, it had not itself undertaken any risk assessments of these.

119 Although the lack of a risk assessment of the dispatch process at platform 10 at Newcastle Central is not directly causal to the accident, had FTPE done one, it may have identified the need for another method of dispatch (paragraph 120) and therefore taken some actions. It has told the RAIB that there was reluctance by some infrastructure managers of stations at which FTPE operated, (however not East Coast) to undertake joint station risk assessments. However, FTPE accept it has a duty under health and safety legislation to undertake risk assessments despite any alleged reluctance from any infrastructure managers concerned (paragraph 163 and Recommendation 4). The ROGS Regs (paragraph 12) also establish a duty of co-operation between duty holders[18].

Alternative dispatch method

120 On a Class 185 unit it is possible for the conductor to operate the door controls from the centre vehicle. A guard's operating panel, known as a GOP, is provided next to a door on each side of the centre vehicle. Conductors, including the conductor involved in the accident, were trained by FTPE to dispatch a train from this position as well as the rear cab. The 'route risk assessment' document (paragraph 115) stated that this was the recommended method of dispatch at platform 10 because of its curvature.

121 Dispatching from the GOP allows the conductor to be at the last passenger door to close. It also means, on a curved platform, that a conductor does not have to walk as far from the train to observe all the passenger doors. However, FTPE conductors have informed the RAIB that on this particular service it can be difficult for them to board the train in a busy vestibule area. Also, the conductor has to move forwards and across the busy carriage to be at the diagonally opposite GOP to control the doors at the next station stop (if the platform is on the other side of the train). Access to the door control panels for the passenger doors on both sides of the train in the rear cab does not present this problem. Unlike the rear cab, the passenger doors do not have a window which can be opened, thereby enabling the conductor to watch the side of the train as it leaves the platform, although there is no rule book requirement for them to do so.

122 First TransPennine Express trains its conductors to dispatch from both positions and leaves it to the conductor's judgement as to which one to use. However, at the time of the accident FTPE had not considered the relative risks of the two methods which could be employed at Newcastle platform 10.

[18] http://www.rssb.co.uk/Library/improving-industry-performance/2009-guide-rssb-duty-of-coop-pt1.pdf.

Assessment and monitoring of conductors

123 The RAIB has found no evidence that a lack of training and experience contributed to the accident. However, FTPE had not obtained any records of the conductor's safety performance from his previous employer; something that its own procedures require. Conductors perform safety critical tasks and FTPE's procedures stated that a qualified conductor joining FTPE should be subject to a training needs analysis (TNA). This allows FTPE to identify what training is needed to supplement a conductor's previous experience. It has stated that this was carried out, but was unable to provide written evidence.

124 The training document used by FTPE for the assessment of conductors' knowledge for them to be competent to operate on a particular route was the same as that used for its drivers and was dated 2008. The majority of the questions were neither applicable to the duties of a conductor, nor specific to risks that conductors may encounter over the route.

Safety critical communications and reporting

125 The occurrence of this accident became known only because a member of the public, who witnessed the event, wrote to First Group's customer relations centre on 6 or 7 June. The incident was not reported by the FTPE staff involved.

126 Evidence from signal box voice records indicates that the driver said to the signaller that 'somebody's had their hand jammed in a door'. The driver has since stated that he was not aware that the person was on the outside of the train and, had he known this, he would have contacted the duty control manager. He has also stated that he told the conductor to report the reason for the train delay to FTPE control. First TransPennine Express has told the RAIB that it is the duty of all train crew to report such incidents, and this requirement is within its driver and conductor training and competency procedures.

127 The conductor stated that he missed a telephone call from the FTPE operations controller shortly after leaving Newcastle, as he was busy assisting the injured passenger. The conductor returned the missed call and the controller asked him for the reason for the delay in departing. During the conversation the conductor stated that 'she had her hand trapped in the doorway' but did not mention that the passenger had been on the outside of the train, or emphasise the safety significance of this. The controller did not ask whether there had been an injury as a result of this, or whether the train had moved during this event.

128 Before the passenger left the train around 10 minutes later, the conductor had written her name and address on a piece of paper. Although the conductor had been trained in completing and submitting incident report forms to the on-board service managers, the RAIB has found no evidence that he did so. Once FTPE managers became aware of the accident, via the customer relations centre, the conductor produced an incomplete report form. He stated that he had placed a copy of this in the service manager's post box shortly after the incident. The RAIB has found no evidence of this action.

129 The First Group customer relations centre did not forward the customer complaint to FTPE until 17 June 2013 as its staff had not been briefed to be aware of possible safety issues that may be described within communications it receives (Learning point 3, paragraph 162).

Rail Industry reporting and monitoring of door trapping and dragging incidents

130 The trapping and dragging incident involving a London Midland Class 350 in January 2012 (paragraph 71) was recorded on RSSB's Safety Management Information System (SMIS). This is a database of national railway incidents and accidents, including near-miss events, and is used to monitor railway safety performance. The earlier London Midland Class 350 incident at Wembley Central station (paragraph 72) was not recorded on SMIS. Railway infrastructure managers and train operators are only required, by Railway Group Standard GE/RT8047, to record train door incidents within SMIS which result in either a fatality or injury (Recommendation 6, paragraph 163 and Learning point 4, paragraph 162).

Previous occurrences of a similar character

131 The RAIB has investigated a previous accident of a person being dragged by a train after becoming trapped in an external door fitted with an obstruction detection system. This system, like that on the Desiros, was designed to fully reopen the doors when obstructed (RAIB report 26/2012[19]). This happened on 12 April 2012 at Jarrow station on the Tyne and Wear Metro (TWM) system.

132 The investigation identified four factors relevant to this accident:

a. the passenger attempted to board a train as the doors were closing;

b. the door did not detect a trapped arm, because there was a fault with the detection system on the particular door involved in the accident;

c. the passenger was unable to pull her trapped arm out, and

d. the driver (solely responsible for the dispatch) did not notice the trapped passenger before departing.

133 An underlying factor in the Jarrow accident was that misuse of doors was commonplace, and this was encouraged by the design of the doors which fully reopened when obstructed. The passenger involved in the Newcastle Central accident, also a user of the Tyne and Wear Metro, has informed the RAIB that she has witnessed passengers holding the doors open so that others could board the train. The Jarrow station investigation identified that there were no additional warnings to advise passengers not to board when the doors were closing and no enforcement of the railway's bye-laws that make it an offence to obstruct the train doors[20] (Learning point 2, paragraph 162).

134 The RAIB made five recommendations to the TWM operator. One of these is relevant to this investigation. This recommended that the operator develop and implement actions to reduce the frequency of door obstruction by passengers into an ongoing long term strategy. This included monitoring the frequency of door obstructions on its network, in order to check the efficacy of the measures implemented.

[19] Available at www.raib.gov.uk/publications/investigation_reports/reports_2012/report262012.cfm.

[20] Railway byelaw 10 (5) states that 'in the case of automatic closing doors, no person shall enter or leave by the door when it is closing.'

135 The TWM operator has reported that it has a strategy in place. To address some of these issues, it has run campaigns to increase the awareness of its passengers of the safe use of train doors. This has included newspaper advertisements, YouTube videos, station announcements and warning stickers on the train doors. It has also begun the implementation of a plan to improve the reliability of door operation and obstruction detection. The effectiveness of these measures is due for review by TWM and the ORR in December 2014.

136 The RAIB has conducted a preliminary examination into an accident that occurred on 29 April 2014 at Thornton Heath station involving a service operated by Southern Trains. A passenger who had alighted from a Class 377 train reported that he was trapped by a closing door as he attempted to rejoin the train. This was not seen by the driver and the train departed. The CCTV images from the platform shows that the passenger did not fall over but was running alongside for a distance of approximately 60 metres before he moved away from the train and then came to a stop. It is not clear from the evidence how, or whether, he was trapped. The passenger later reported that his right arm and hip were painful. He was advised by train staff to attend hospital which he said he would do later.

137 The train was operated by a driver alone (ie with no conductor); a method of train operation known as *Driver Only Operation* (DOO). Since the platform was unstaffed the driver was responsible for the safe dispatch of the train. This dispatch method requires the driver to open and close the doors, and to carry out the train safety check to ensure that it is safe for the train to depart. To enable this safety check, there are CCTV cameras mounted on each vehicle which transmit moving images of the side of the train closest to the platform to monitors located in the driver's cab. The CCTV evidence indicates that the passenger moved close to the doors as they were closing. It is not however possible to determine whether his hand was between the closed doors.

138 The external passenger doors on the Class 377 were designed to comply with passenger door standard GO/OTS300 (paragraph 57). This preceded the standard that applied when the train that was involved in the Newcastle Central accident was approved. Post-incident testing found that the interlock circuit, which enabled the train to be driven out of the platform, could not be completed when a 25 mm obstruction was placed between the door edges (thereby complying with the requirement for the train doors to detect the presence of an obstruction of 25 mm or greater). However, the design of the doors was such that they were able to close and lock with a hand between their closing edges (ie an obstruction less than 25mm).

139 The sequence of events and witness evidence strongly indicates that, although he understood that it was a requirement, the train driver did not carry out an adequate final safety check before departure. This was because:

a. he believed that if somebody was trapped in the train doors the door interlock circuit would detect it (ie he was, to a degree, relying on the interlock as an indication that it was safe to depart); and

b. he had not seen anyone near the train's doors when he closed them (the passenger was not standing near the passenger doors at the point the driver decided to close them, and only moved towards them as they were closing).

140 As soon as the driver selected power to start the train, the in-cab dispatch monitors automatically switched off. Southern Trains had enabled this feature because it believed that leaving the monitors switched on may distract drivers from looking ahead as the train departs from stations.

141 The RAIB investigation into an accident on 28 January 2011 at Brentwood station[21] identified that a possible causal factor in this accident was the driver of a DOO train not undertaking the train safety check (Learning point 1, paragraph 162).

[21] RAIB report 19/2011, November 2011. Available at www.raib.gov.uk/publications/investigation_reports/reports_2011/report192011.cfm.

Summary of conclusions

Immediate cause

142 The train moved with the passenger's wrist trapped in the closed door.

Causal factors

143 The causal factors were:

a. The passenger attempted to board the train as the door was closing (**paragraph 77, no recommendation**).

b. A characteristic of the Class 185 doors was that a wrist could be trapped and not detected, thereby allowing the train to move (**paragraph 81, Recommendations 1 and 2**).

c. The conductor did not see the passenger trapped in the door because he did not do a final safety check before dispatching the train. This was because he either made an error due to confusion, or he consciously ignored what he had been trained to do (**paragraph 84, no recommendation**).

Underlying factor

144 The underlying factor was that although Siemens, FTPE and HMRI were aware of the possibility of a trapping and dragging accident as a result of the undesirable characteristic of the original door design, the risk of this specific hazard was not properly assessed, nor was there any consideration of additional safety measures to minimise any risk (**paragraphs 100 and 110, Recommendations 3 and 4**).

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

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

145 In 2006 the ROTS Regs were replaced by the ROGS Regs (paragraph 12). The ROGS regulations implement part of the 2004 European Railway Safety Directive (2004/49/EC) in Great Britain.

146 The ROGS Regulations oblige transport operators to have a safety management system and to carry out a 'suitable and sufficient' assessment of the safety risks involved in running a transport system. It is a further requirement that it must apply the relevant parts of the EC regulation 352/2009 on a *common safety method* for risk evaluation and assessment[22]. This requires that risk assessment is undertaken on significant proposed changes to railway systems, such as the introduction of new vehicles. It requires that all foreseeable hazards of the system are identified and analysed. The sources of hazards includes:

a) normal and degraded modes of operation;

b) consideration of the system's life cycle, ie hazards arising from its design, operation, and maintenance, etc;

c) human factors; and

d) foreseeable modes of failure.

147 The regulations also places a duty on the proposer of a significant change to create and maintain a record of the hazards which should then be incorporated within the operator's safety management system.

148 For significant changes to railway systems, the common safety method requires that the process by which risk is being managed is subject to independent assessment. This is the role of the project's assessment body. Their role is to audit and check that:

a) a robust process of hazard identification has been used and appears to be complete;

b) the risk classification and acceptance methods have been correctly applied;

c) there is a demonstration of compliance with safety requirements; and

d) hazards have been recorded, closed and validated.

149 In 2006, responsibility for health and safety policy and enforcement on the railways moved from HSE/HMRI to the ORR. The role of the ORR under the ROGS Regulations is to monitor the safety management systems of others. They are no longer required to approve changes to railway systems. It is for this reason that the RAIB is making no recommendation to the ORR (HMRI's successors).

[22] RSSB guidance document refers, available at http://www.rssb.co.uk/improving-industry-performance/management-of-change.

150 First TransPennine Express has reported to the RAIB that since the accident it has completed station operational risk assessments for all of the stations at which its calls, including Newcastle Central station. This has been done following the guidance within the Rail Industry Standard RIS-3703-TOM (paragraph 114). It has created risk reduction action plans where issues have been identified (paragraph 163, Recommendation 4).

Other reported actions

151 The RAIB issued a notice of urgent safety advice on 2 August 2013 once the method of overcoming the detection of the sensitive edges had been confirmed. This was sent to operators of Desiro UK fleets with electrically operated sensitive door edges. The notice advised them that a wrist could become trapped and to gather data on the frequency of trapping incidents. It also advised them to consider the need for additional operational and/or technical measures to manage the risk of passengers being trapped and dragged, paying particular attention to curved or higher risk platforms.

152 At the request of the RAIB, FTPE, London Midland and Heathrow Express reviewed door trapping incidents on their respective fleets fitted with electrical sensitive door edges. The FTPE Class 185 and London Midland Class 350 door trapping incidents are described in paragraph 66 onwards.

153 Heathrow Express records between 2010 and April 2014 indicate that there were two incidents of passengers being trapped in Class 360 doors with the door interlock obtained. In both of these incidents the trappings were detected by the train crew, or platform staff, before the train moved.

154 On 24 October 2013 this urgent safety advice was sent to the European Rail Agency (ERA) for dissemination across the European Union via its Safety Information System (SIS). Information within this system is available to EU national safety and investigation authorities.

155 On 5 August 2013, FTPE submitted a National Incident Report (NIR). This is a national system to alert the UK railway industry to safety issues that arise. This alerted railway infrastructure owners and operators to the risk of trapping passengers in this design of train door.

156 First TransPennine Express has reported that it has:

a. Rebriefed its conductors on the need to undertake thorough checks when dispatching trains.

b. Reassessed the risk of a fatality and injury from a trapping and dragging accident (paragraph 105) and, together with Siemens, is appraising options of modifying the door sensitive edges.

c. Added signs, assisted by Siemens, to all the passenger doors of its Class 185 and 350/4 units warning passengers not to obstruct the doors when they are closing.

d. Revised its procedures to improve the reporting and assessing of safety related matters including guidance to its customer relations department to raise its awareness of possible safety issues that may be within communications from its customers.

e. Stopped operating services from platform 10 at Newcastle Central station (as from 10 February 2014).

f. Increased the frequency of its planned unobtrusive conductor monitoring visits by 30%. The choice of locations is now based upon risk and these have been supplemented with additional monitoring visits by the On Board Service and Operations Teams.

g. Begun to deliver an accident investigation and risk management course to its team leaders, health and safety representatives and managers.

h. Taken disciplinary action with regard to the conductor.

157 London Midland has reported that it has:

a. Issued an operational notice to its senior conductors and train dispatchers highlighting this incident and the hazard exposed.

b. Been running a campaign since early 2013 at stations (involving a mix of posters, station and train announcements, and passenger information system display messages) to influence passenger behaviour away from trying to board/alight trains when the doors are closing.

c. Fitted warning signs on all doors of its current Class 350 fleets (with the assistance of Siemens). It is planning to fit these to its new Class 350/3 trains by the time they come into service.

158 Heathrow Express has reported that it has:

a. Completed a review of its station dispatch risk, including changes to the competency management system for dispatchers in order to improve monitoring, assessment and knowledge.

b. Added signs, assisted by Siemens, to all passenger doors of its Class 360/2 units warning passengers not to enter the train when the doors are closing.

159 Siemens has reported that its latest Desiro trains being supplied to the UK (such as the Class 380 and Class 700) have electrically operated doors, rather than those on their Class 185, 350 and 360/2 units which are pneumatically operated. It reports that the doors on these more recent units have stiffer leading edges and it is not possible to deflect them in the same manner as those on the Class 185 units.

160 In 2013, the RSSB Board established a Platform Train Interface Strategy Group at the request of railway industry parties. The purpose of this is to develop a strategy for managing the risk at platform edges. The development of this strategy will include consideration of passenger behaviour in relation to train doors and the ways in which they can become trapped.

161 RSSB has reported that the Railway Group Standard for passenger doors, GM/RT2473 (paragraph 45) will be superseded by the new European standard EN14752. The obstruction tests specified within it are the same as the Railway Group Standard tests. RAIB has consulted with RSSB as to how best capture the learning from this accident with respect to obstruction detection (paragraph 163, Recommendation 5).

Learning points

162 The RAIB has identified the following learning points[23]:

1 Those responsible for train dispatch should ensure that they undertake a thorough train safety check as defined in module SS1 of the rule book and should never solely rely on any indication given by the train door interlock circuit (paragraphs 95, 139a and 141).

2 Train designers and operators should make themselves aware of public perceptions of how train doors operate when they come into contact with obstructions and take account of this in both the design and testing of doors, and dispatch procedures. Train operators should also seek ways in which they can positively influence the behaviour of passengers to minimise door trappings (paragraph 133). (Note: RSSB has confirmed to the RAIB that passenger behaviour at train doors will be considered by the cross-industry Platform Train Interface Strategy Group (paragraph 160)).

3 Those who work for train operating companies who receive information from their customers should be trained to identify safety issues within customer communications and alert those responsible for safety in a timely manner (paragraph 129).

4 Train operating companies should share with other operators, designers and maintainers of similar fleets (for example by using the existing NIR or SMIS processes), details of train door trapping incidents and precursor events that may indicate shortcomings in safety equipment or systems, either existing or emerging, which could lead to injuries or fatalities (paragraph 130).

[23] '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 the RAIB has not identified management issues that justify a recommendation) and the consequences of failing to do so. They also record good practice and actions already taken by industry bodies that may have a wider application.

Recommendations

163 The following recommendations are made[24]:

1 *The intent of this recommendation is to reduce the risk to passengers due to trapping and dragging incidents by taking into account the learning from this accident.*

Operators of Siemens UK Desiro trains fitted with electrically operated sensitive edges should re-assess the risk of injuries and fatalities due to a trapping and dragging incident in light of failures identified in this report and take appropriate action to reduce the risk. This should take account of historical data, the incidents highlighted in this report and precursor events to trapping and dragging. This risk assessment should take into account observed passenger behaviour (eg by monitoring passenger attempts to reopen closing doors) and estimated human error rates within the dispatch process (paragraph 143b).

2 *The intent of this recommendation is to reduce the risk to passengers due to trapping and dragging incidents by modification of future door designs.*

Siemens should redesign the doors, as used on the Class 185 and other similar units, for future vehicles supplied to the UK, to reduce the probability of a passenger being trapped in them but not detected by the door control system. This could be achieved by redesigning the sensitive edges or by other means (paragraph 143b).

continued

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

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

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

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

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

3 *The intent of this recommendation is to reduce the risk to passengers due to hazards from trains supplied by Siemens which are either discovered at the design stage, or that subsequently emerge during service.*

Siemens should review and, where appropriate, improve their design processes to ensure that they fully identify record and assess hazards associated with the design of their trains. The train operator, or those with operational experience, should be involved in the hazard identification and review process to ensure that this is considered in any design decisions. Any hazards identified following the design phase should be fully assessed, including consideration of the potential for redesign to manage the residual risk. Where this is not practicable, the operator of the train and/or the maintainer should be made aware of the hazard and the residual risk so that suitable mitigation measures and monitoring arrangements can be put in place.

Siemens should also seek to ensure that it is kept aware of problems that emerge during service so that the need for subsequent design modifications can be assessed as necessary (paragraph 99).

4 *The intent of this recommendation is to reduce the risk to passengers due to hazards from trains operated by First TransPennine Express by implementing a process for the logging of hazards and the management of risk associated with each. It is also intended that the recording of hazards should be sufficiently visible to its staff so that awareness of them is maintained, possible precursors established (eg near-misses) and monitored and regularly re-assessed.*

First TransPennine Express should continue to review and, where appropriate, improve its safety management processes to ensure that it has a system for the identification and recording of hazards, assessment of the risk associated with each, and management of the implementation of any necessary control measures. By means of these processes, FPTE should:

a) manage risk associated with the original design features of the trains it operates, and those that emerge during operations, inspections and maintenance, or when changes are made to equipment and operational practice (paragraph 110);

b) develop a time bound programme for the implementation of control measures that have been identified; and

c) track the implementation of any control measures, including those identified during its station risk assessments (paragraph 150).

This recommendation may be applicable to other train operating companies.

continued

5 *The intent of this recommendation is to reduce the risk to passengers due to trapping and dragging incidents by ensuring that door obstruction detection systems on new trains, both in the UK and Europe, cannot be readily overcome.*

RSSB should recommend to the British Standards Institution (BSI) that in the forthcoming BS EN version of the European standard (EN 14752 Railway applications - Bodyside Entrance Systems for rolling stock) the UK National Foreword informs readers of the possibility of entrapment even on correctly adjusted doors that comply with the specified obstruction tests (paragraph 161). Additionally, RSSB should recommend to the BSI that in the formal vote on this emerging European standard, it includes a request to review the obstruction test requirements to reduce the probability of trapping and dragging and to make reference to either this investigation report, or the urgent safety advice issued by the RAIB to the European Rail Agency (ERA) on 24 October 2013, reference 665/02 on ERA's Safety Information System (paragraph 154).

6 *The intent of this recommendation is for RSSB to consider what additional data needs to be captured within its Safety Management Information System (SMIS) to allow a more complete evaluation of the risk of trapping and dragging events on the national network.*

RSSB should identify any additional data that should be captured within SMIS from incidents of persons trapped by train doors, who are outside the train which subsequently moves, whether this results in injury or not. This data should be collected and used by railway undertakings to monitor such events and inform decisions to reduce this risk (paragraph 130).

Appendices

Appendix A - Glossary of abbreviations and acronyms

ALARP	As Low As is Reasonably Practicable
CCTV	Closed circuit television
CSM	Common Safety Method
DKS	Door key switch
DMU	Diesel multiple unit
DOO	Driver only operation
ERA	European Rail Agency
FRI	Fatigue and Risk Index
GOP	Guard's operating panel
HMRI	Her Majesty's Railway Inspectorate
ORR	Office of Rail Regulation
RGS	Railway Group Standard
SFAIRP	So Far As Is Reasonably Practicable
SMIS	Safety Management Information System
TRTS	Train-ready-to-start control
TWM	Tyne and Wear Metro
VAB	Vehicle acceptance body

Appendix B - Glossary of terms

Automatic route setting	A computer based signalling system that can set routes for trains without the involvement of a signaller.
Common safety method	A European Commission Regulation (EC) 352/2009 that aims to harmonise the approach to risk assessment and evaluation of significant changes to railway subsystems which have safety implications ie technical, operational and organisational.
Diesel multiple unit	A train made up of multiple units that is powered by a diesel engine.
Driver only operation	A train dispatch method which is solely managed by the driver ie there is no assistance from a conductor or platform staff.
Door key switch	A switch which is operated by a railway carriage door key.
Fatigue and Risk Index	A numerical model used to assess the degree of fatigue of workers from their shift patterns. www.hse.gov.uk/research/rrhtm/rr446.htm
'Off' indicator	An illuminated indicator provided at a platform to inform the conductor or platform staff that the signal beyond (ahead of) the train shows a proceed aspect and it is safe to inform the driver to depart.
On-train data recorder	A data recorder storing measurements about the train's performance.
Railway Group Standard	A Railway Group Standard (RGS) is a standard that defines what must be done to achieve technical compatibility on the GB mainline network.
Train-ready-to-start control	An electrical switch provided on the platform to allow the conductor or platform staff to indicate to the signalling system that the train is ready to depart.
Vehicle acceptance body	A body accredited by RSSB to assess the compliance of vehicles and related maintenance procedures with rail industry standards and issue certificates of engineering acceptance.

Appendix C - Key standards

GM/RT2000 issue 2, dated October 2000 (now superseded)	Engineering acceptance of rail vehicles
GM/RT2473, issue 1, dated February 2003 (now superseded)	Power Operated External Doors on Passenger Carrying Rail Vehicles
GO/OTS300, issue 1, Rev A, December 1993 (now superseded)	Power Operated External Doors on Passenger Carrying Rail Vehicles

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