



Rail Accident Investigation Branch

Rail Accident Report



Pushchair trapped in tram doors and dragged, Nottingham 15 December 2017

Report 15/2018
September 2018

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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Preface

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

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

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

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

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

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

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

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

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Contents

Preface	3
Summary	7
Introduction	8
Key definitions	8
The incident	9
Summary of the incident	9
Context	9
The sequence of events	16
Key facts and analysis	20
Identification of the immediate cause	20
Identification of causal factors	20
Identification of underlying factors	28
Factors affecting the severity of consequences	31
Observation	32
Previous occurrences of a similar character	34
Summary of conclusions	36
Immediate cause	36
Causal factors	36
Underlying factors	36
Factors affecting the severity of consequences	37
Additional observation	37
Previous RAIB learning point relevant to this investigation	38
Recommendations that are currently being implemented	39
Actions reported as already taken or in progress relevant to this report	40
Recommendations and learning point	41
Recommendations	41
Learning point	42

Appendices	43
Appendix A - Glossary of abbreviations and acronyms	43
Appendix B - Investigation details	44
Appendix C - Nottingham Trams' tram stop risk assessment	45
Appendix D - RAIB Urgent Safety Advice	46

Summary

At around 13:29 hrs on 15 December 2017, an empty pushchair became trapped on the outside of a tram at Radford Road tram stop, Nottingham, when its plastic rain cover was caught between closing doors. It was then dragged to the next tram stop where it was crushed against the kerb. Nobody was physically injured.

A passenger had pushed the pushchair off the tram as the doors were closing because she wished to remain with another passenger who had been removed from the tram by a Nottingham Trams' travel officer. The rain cover was too thin to trigger the system which automatically reopens the doors if an obstacle is detected. The final visual door check, which drivers are required to carry out before departing from a tram stop, did not result in the driver being aware that the pushchair, shown as a small object on a CCTV monitor in his cab, was in an unsafe position. A larger image of the pushchair was not available to the driver when doing this check because of a modification to the tram's CCTV system. The travel officer and other staff at the tram stop were unable to stop the tram departing, and the tram driver remained unaware of the pushchair until he arrived at the next tram stop.

Inadequate risk assessment by Nottingham Trams is the probable underlying cause for its staff placing inappropriate reliance on the doors closed indication, being unaware of the importance of the final door visual check, and the way in which the tram CCTV arrangements were modified. The incident also showed that training of travel officers was inadequate.

The RAIB investigation has resulted in two recommendations, both addressed to Nottingham Trams, and one learning point. The first recommendation seeks improved arrangements for preventing trap and drag events. The second requires improvements to Nottingham Trams' risk assessment processes. The learning point reminds all tram drivers that they must carry out a thorough final door visual check, and not rely solely on doors closed indications, when deciding whether it is safe for their tram to depart.

Introduction

Key definitions

- 1 This report uses metric units and contains abbreviations, explained in Appendix A. Sources of evidence used in the investigation are listed in Appendix B.

The incident

Summary of the incident

- 2 At around 13:29 hrs on 15 December 2017, an empty pushchair became trapped on the outside of a set of closed and locked doors of a tram at Radford Road tram stop, Nottingham (figures 1 and 2). The pushchair was trapped by its plastic rain cover, which had got caught between the edges of a pair of closing doors.
- 3 The tram driver was not aware of the trapped pushchair before starting the tram, or subsequently as he drove the tram from Radford Road tram stop to Hyson Green Market tram stop, around 400 metres away. Nobody was physically injured but the pushchair was destroyed when it was crushed between the tram and the kerb as the tram arrived at Hyson Green Market tram stop.

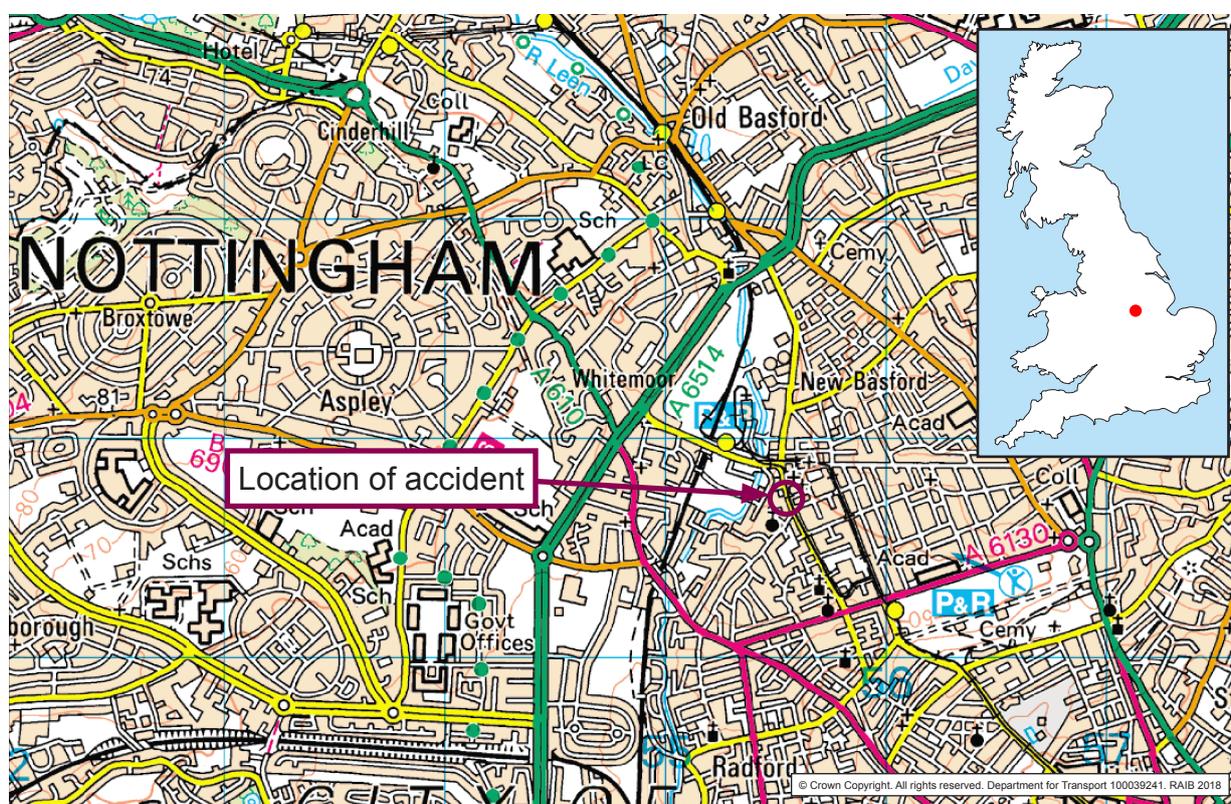


Figure 1: Extract from Ordnance Survey map showing location of incident

Context

Location

- 4 Radford Road tram stop is on the tram routes from Hucknall to Toton Lane and from Phoenix Park to Clifton South (figure 2). The tram tracks at this location are laid in a road shared by trams and road vehicles. Radford Road carries road vehicles in both directions, but trams only head south along it, towards Hyson Green Market and Nottingham city centre (figures 3 and 4).

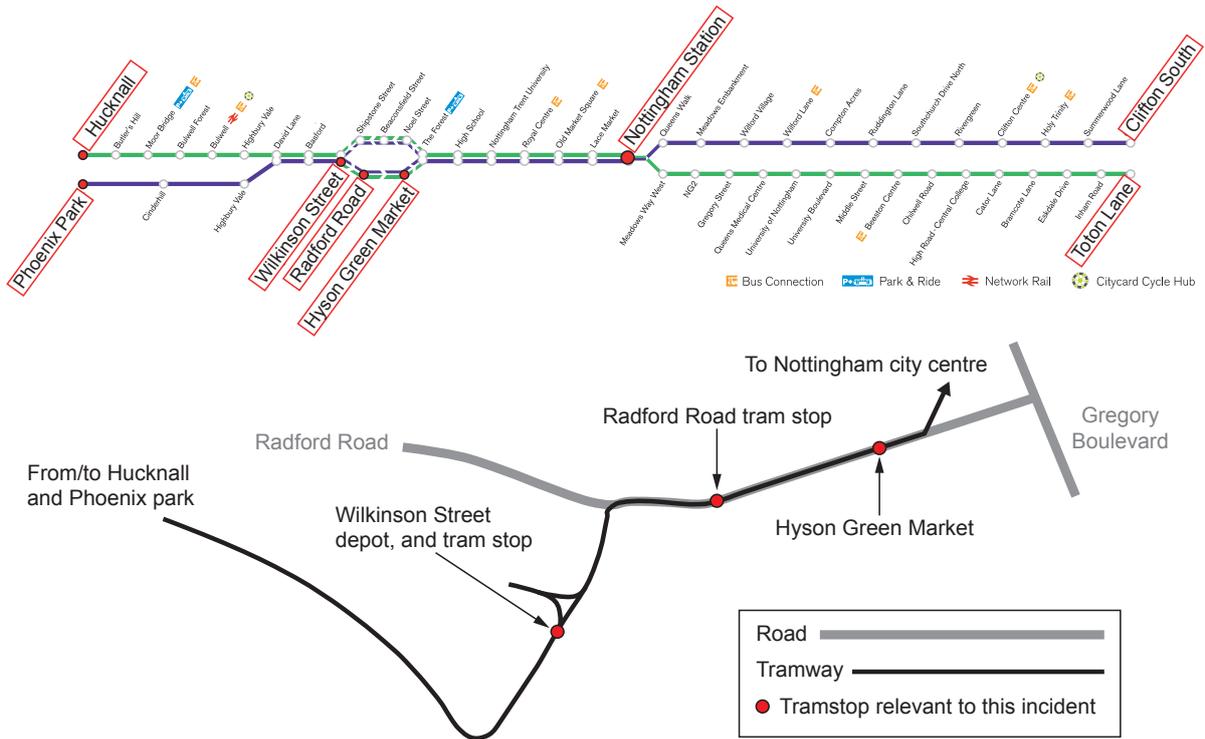


Figure 2: Radford Road in the context of the Nottingham tram system



Figure 3: Google Earth image showing location of Radford Road, Nottingham

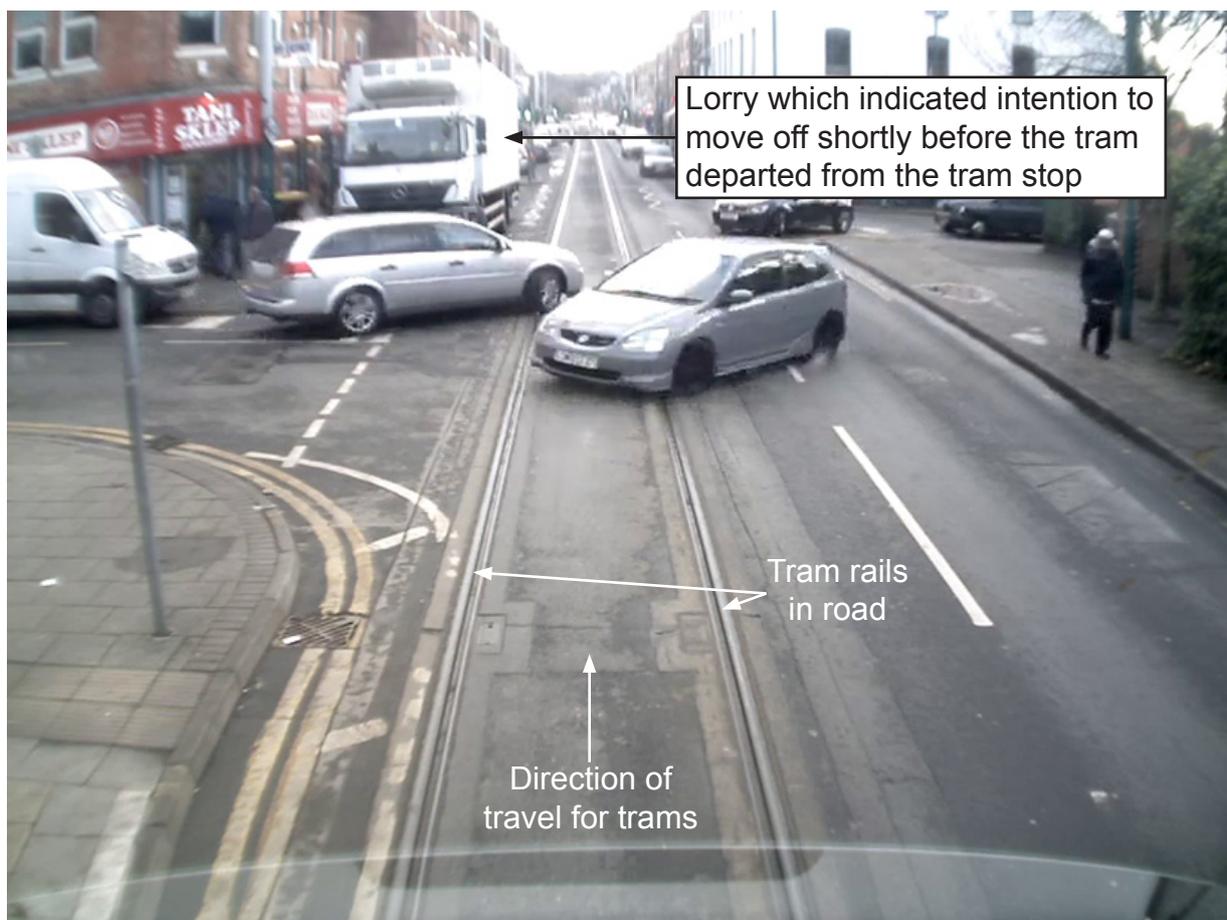


Figure 4: View of the road beyond Radford Road tram stop from forward-facing CCTV fitted to the tram involved, just before the incident (image courtesy of Nottingham Trams)

- 5 The tram stop has a raised kerb to make the pavement level with tram floors. The tram stop includes a shelter, and a combined ticket machine and help point (figure 5) which is connected to Nottingham Trams' control centre located at Wilkinson Street depot. Images from closed-circuit television system (CCTV) cameras at the tram stop are transmitted to the control centre for continuous recording and for live viewing if necessary.

Organisations involved

- 6 Operation and maintenance of the tramway is undertaken by Nottingham Trams Ltd (referred to as Nottingham Trams in this report).
- 7 Alstom (UK) Ltd built, supplied and maintain the tram involved in the incident.

Tram involved

- 8 The tram involved in the incident, tram 237, was one of a batch of Citadis type trams built by Alstom between 2013 and 2014. These trams have a maximum permitted speed of 70 km/h, are 32 metres long, and can carry over 200 passengers.

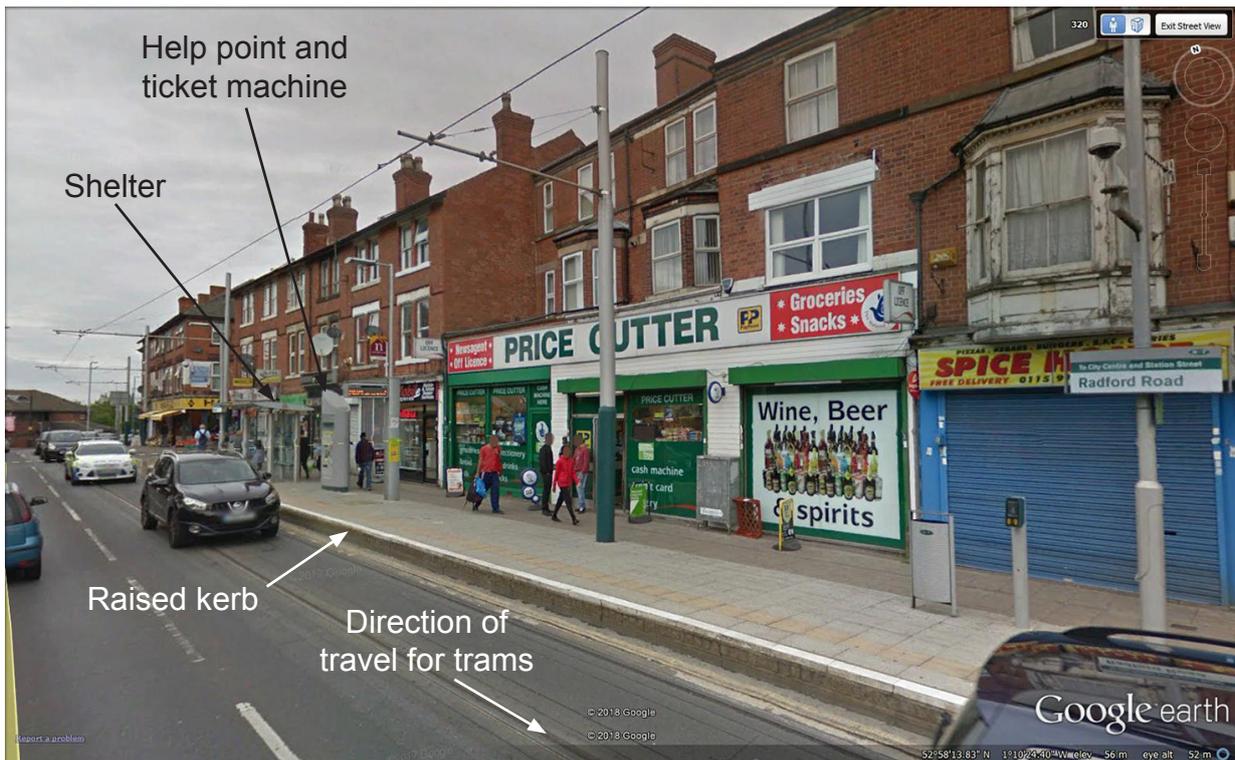


Figure 5: Radford Road tram stop

9 The Citadis trams are formed of five modules. The driving cab modules at each end of the tram have a single sliding passenger door on each side, the centre module has no doors, and the two intermediate modules each have two double sliding doors on each side (figure 6). The door arrangement includes a system for detecting objects if they are trapped between closing doors. If no obstacles are detected as the doors close, they lock and an electrical interlock circuit is made (the interlock circuit permits the driver to take traction power to move the tram).

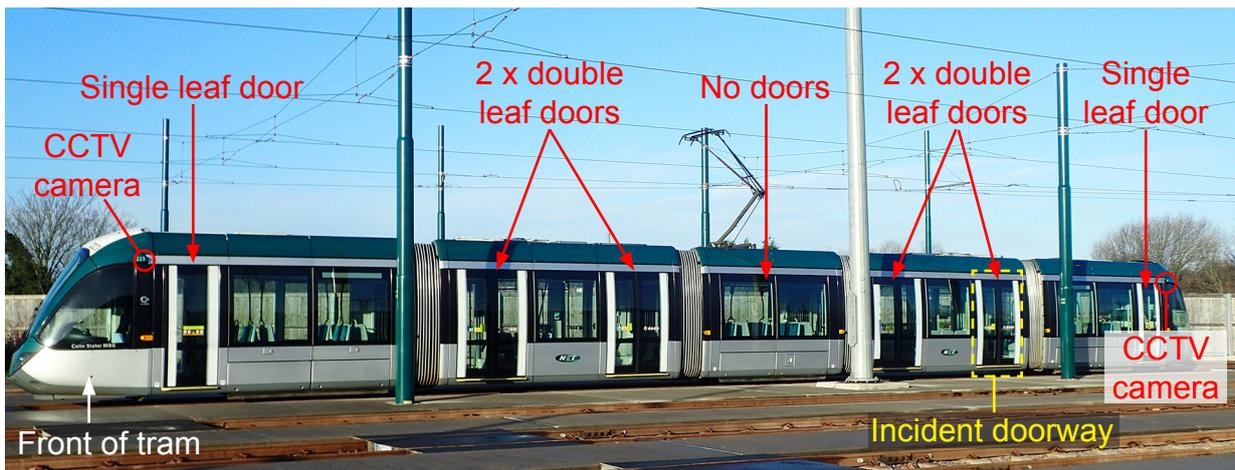


Figure 6: A Citadis type tram used on the Nottingham tramway

- 10 Operation of the passenger doors is enabled by the driver, using push-buttons in the driving cab, so the doors can then be opened as required by passengers using push-buttons on the doors¹. When preparing to depart, the driver operates a push-button in the driving cab which closes and locks all doors. When the doors are closed and locked with nothing detected trapped between them, the following happen simultaneously:
- a chime sounds in the driving cab;
 - a green light illuminates on the drivers control panel in the driving cab;
 - the colour of the doors shown on the drivers graphical information display changes from white to green (figure 7); and
 - the images displayed on the CCTV monitors in the driving cab change (paragraphs 13 and 14).

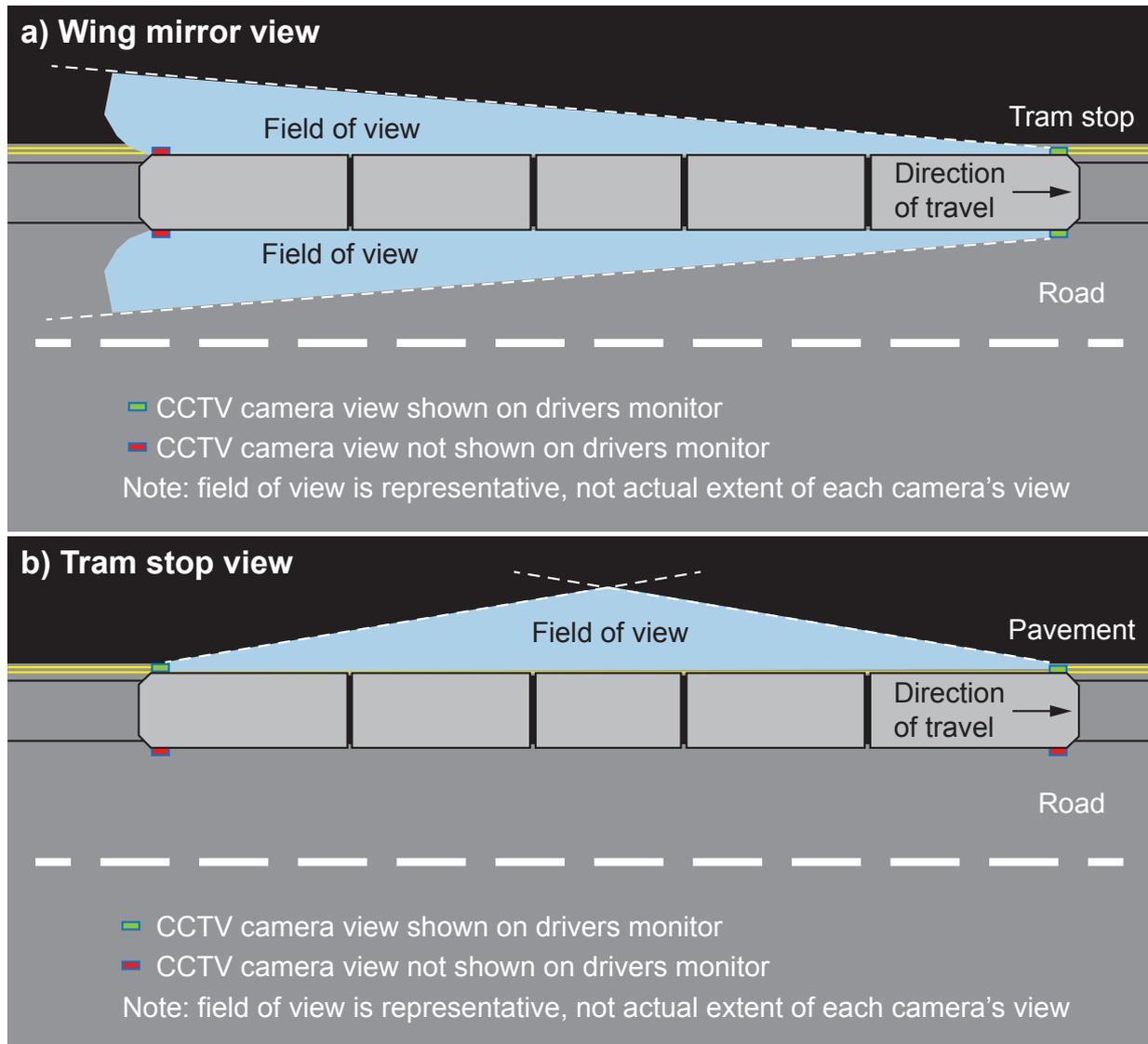


Figure 7: Driving cab monitors

- 11 The tram is fitted with three types of CCTV system: forward and rear-facing CCTV, internal CCTV, and bodyside CCTV. The body side mounted cameras fitted at each end of the tram (looking towards the opposite end of the tram, figure 6) are linked to two monitors in each driving cab, one to the left, and one to the right of the driver, and normally show the images from the bodyside mounted cameras (figure 7).
- 12 The trams are not fitted with traditional road vehicle wing mirrors (paragraph 66) so, in order to see what is happening alongside and behind them, tram drivers use images from bodyside CCTV cameras (figure 8a). In this configuration, the front left CCTV camera is linked to the left-hand monitor in the drivers cab, and the front right CCTV camera is linked to the right-hand monitor in the drivers cab.
- 13 When a tram reaches a tram stop and the passenger doors are opened, the monitor adjacent to the tram stop continues to show that side of the tram using images from the front CCTV camera. The images on the monitor furthest from the tram stop change to show the side of the tram adjacent to the tram stop viewed from the rear CCTV camera on that side of the tram (figure 8b).

¹ The trams are fitted with a system that automatically closes an open door after a period of time to maintain a stable temperature inside the tram. In this situation the doors are not mechanically locked and passengers are still able to open any doors that have closed in this way by pressing the push-buttons located at each doorway.

- 14 When the doors are detected as closed and locked, the monitor views immediately change automatically to show the 'wing mirror' view required before the tram can move off (figure 8a). Although only two camera views are shown to the driver at one time, images from both front and both rear CCTV cameras were recorded at all times and were available for the RAIB investigation.



Figures 8a and 8b: Tram body side CCTV

- 15 The RAIB found no evidence that the condition or maintenance of tram 237 was a factor in this incident.

People involved

- 16 The driver had just over two years' tram driving experience since completing his training. He was last assessed as competent to drive trams during a routine driving assessment in March 2017. He was subject to Nottingham Trams' routine medical assessment process and was considered fit to drive trams without the need to wear glasses. The driver stated he felt well rested before the incident on 15 December 2017. His work roster for the period leading up to the incident did not contain duties likely to cause significant fatigue risk at this time. He stated that he was not preoccupied with any work or personal issues.

- 17 Three travel officers were present when the incident occurred. Their duties included patrolling the tram network to check that passengers were travelling with valid tickets or travel cards. The three travel officers involved in the incident were:
- travel officer 1 and travel officer 2 who had both qualified in September 2017, about three months before the incident; and
 - travel officer 3 who had qualified in July 2015.
- 18 The travel officers' work rosters for the period leading up to the incident did not contain duties likely to cause significant fatigue risk at this time. They stated that they did not feel fatigued at the time of the incident and were not preoccupied with any work or personal issues.
- 19 The family involved in the incident, a father, mother and their younger son, were regular users of the tramway. They used it most school-term weekdays to take their elder son to and from school, and occasionally at weekends.

External circumstances

- 20 The incident occurred during daylight on an overcast day when visibility was not particularly affected by sunlight or shadows.
- 21 Tram 237 was busy. The internal CCTV showed that, in addition to seated passengers, many passengers were standing.
- 22 The area around the tram stop was busy at the time of the incident. Forward-facing CCTV showed that, although no cars overtook the tram while it was stationary for around 20 seconds at the tram stop, four vehicles had stopped behind it, with a fifth approaching from behind as the tram moved off. During this time, forward-facing CCTV images also show that the road ahead of the tram was busy with several vehicles passing the tram in the opposite direction and other vehicles emerging from left and right road junctions just ahead of the tram (figure 4). A lorry was parked alongside the road and began to indicate its intention to cross over the tram track around four seconds before the tram moved off.

The sequence of events

Events preceding the incident

- 23 The driver booked on at Wilkinson Street depot at 06:22 hrs. He drove between Phoenix Park and Clifton South before returning to Wilkinson Street for a break at the depot from 10:28 hrs to 11:25 hrs. He next drove to Toton Lane, returning to Wilkinson Street at 13:12 hrs.
- 24 The family involved in the incident boarded tram 237 at Moor Bridge, seven stops from Radford Road, at around 13:15 hrs. Initially they sat adjacent to each other in the fourth module. The father gave up his seat to an elderly passenger at Bulwell, and found an empty seat in the rear (fifth) module as the tram travelled between David Lane and Basford. The mother remained where she was, holding her young son in her arms with their pushchair close by (figure 9a).
- 25 When tram 237 arrived at Wilkinson Street at around 13:26 hrs, the three travel officers boarded, and the incident driver took over from an incoming driver. Shortly after departing from Wilkinson Street, travel officer 1 began checking passenger travel cards and tickets at the rear of the tram. The family required tickets for both adults and the father presented travel officer 1 with a valid day ticket and three travel cards (one for an adult, and two for under 19s). Travel officer 1 scanned the travel cards using a digital card reader and all showed as not having being validated for the journey². To resolve the issue, travel officer 1 told the father that they would need to get off the tram at the next stop, Radford Road. Travel officer 1 used her radio to make travel officer 2 and travel officer 3 aware of the need for all the travel officers to get off the tram to deal with the family's non-validated travel card.

Events during the incident

- 26 When the tram arrived at the tram stop, the father and travel officer 1 were discussing the need to get off the tram to resolve the travel card issue. Around five seconds after the tram stopped at Radford Road, travel officer 1 and the father walked forward to the open doors of the fourth vehicle so the father could speak to his wife. Travel officer 1 was walking slightly ahead of the father as they walked towards the open doors. As the father walked past his wife, he told her that they had to get off the tram to resolve the travel card issue (figure 9b).
- 27 At the moment travel officer 1 arrived at the open doors, just ahead of the father, the driver, unaware of travel officer 1's intentions, pressed the doors close push-button in the driving cab. This initiated the three-second door closure warning comprising a flashing orange light above the doorway and an audible warning tone. Travel officer 1 and the father got off the tram as the mother, carrying their son, manoeuvred the pushchair past other passengers (figures 9c and 9d). Just as the mother arrived at the doors with the pushchair, the doors began to close (figure 9e). She pushed the pushchair onto the platform and pulled her arm back inside the tram before the doors fully closed. However, the plastic rain cover attached to the pushchair then became trapped in between the closed and locked doors.

² The 'pay as you go' (Robin Hood) card presented by the father should have been validated at the start of the incident journey. The father stated it had been used for a return journey earlier in the day so he did not think he needed to validate it again (if it had been validated for this further journey no money would have been deducted from the card).

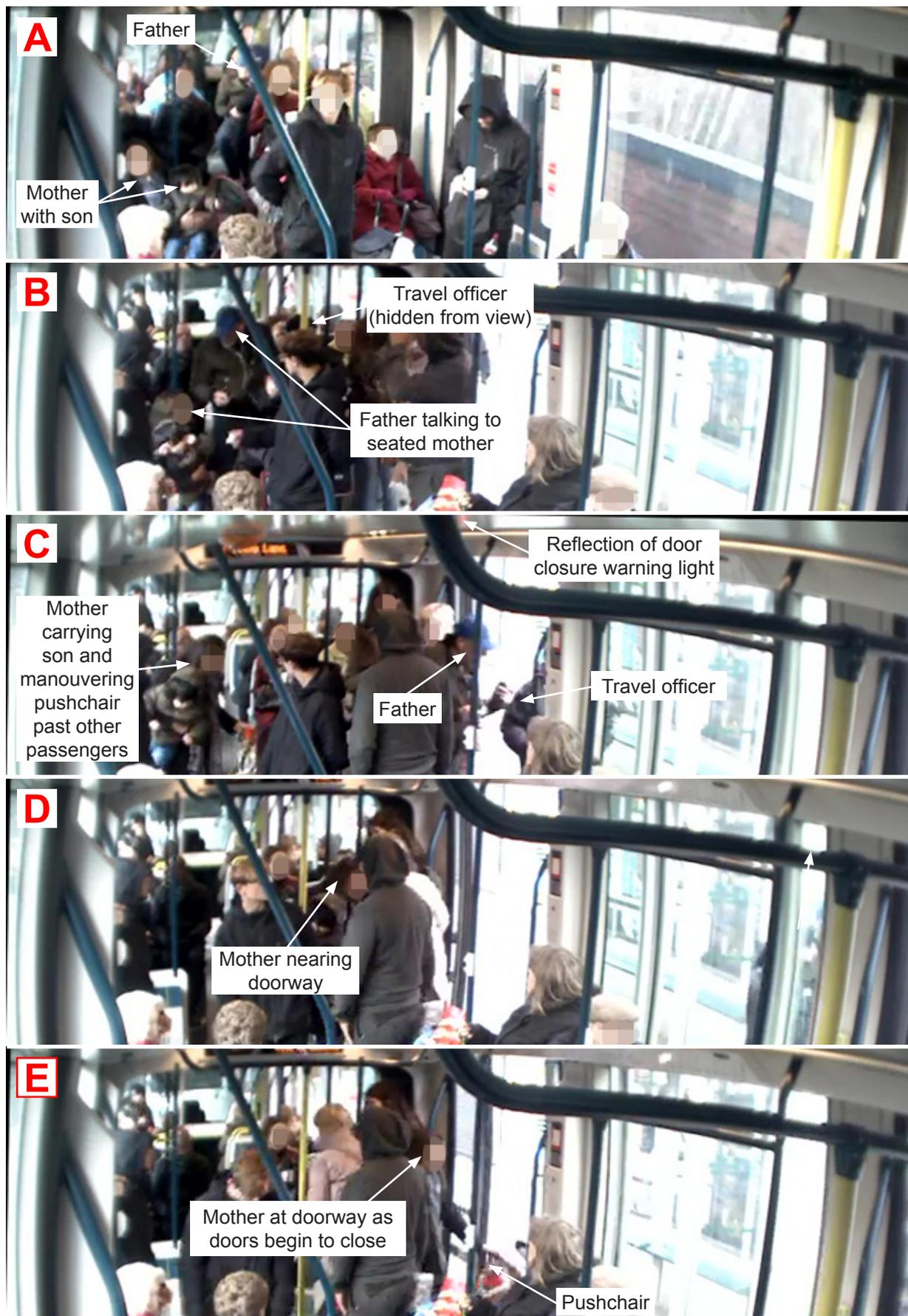


Figure 9: Passengers and travel officer movements (internal tram CCTV images courtesy of Nottingham Trams): a) Initial positions at tram stop; b) Father speaking to mother; c) Father and travel officer leaving tram; d) Mother nearing door; e) Mother at doorway

- 28 When the tram doors had closed and locked, travel officer 3 saw the trapped pushchair (figure 10). He brought it to the attention of travel officer 1 who then tried to free the pushchair. At the same time, travel officer 3 and travel officer 2 turned to the front of the tram to try and get the drivers attention by waving their arms above their heads. As the tram began to move travel officer 1 grabbed hold of the pushchair but was not able to pull it free and the tram left the tram stop with the pushchair trapped in the doors.



Figure 10: Travel officers trying to attract the tram driver's attention (tram stop CCTV image courtesy of Nottingham Trams)

Events following the incident

- 29 The mother tried to contact the driver using a help point on the tram. The driver has stated that he did not hear anyone when he returned the help point call, so looked at images from the tram's internal CCTV (paragraph 86). He saw what he believed to be a woman involved in a heated discussion with another passenger, and concluded that he should continue towards the next tram stop (Hyson Green Market).
- 30 During this journey, the driver did not notice the trapped pushchair (paragraph 83). It did not collide with anything during this time, but it was crushed as it passed into the gap between the side of the tram and the edge of the Hyson Green Market tram stop.

- 31 The driver called Nottingham Trams control room to report the incident when the tram arrived at Hyson Green Market, after he became aware of what had happened. The controllers reviewed the CCTV from Radford Road tram stop and, on realising the seriousness of the incident, instructed that the tram and staff return to Wilkinson Street depot. The tram was then subject to post-incident testing and the driver was screened for the presence of drugs and alcohol (the results were negative).
- 32 On 7 February 2018, the RAIB issued urgent safety advice (appendix D) relating to the importance of tram drivers carrying out an effective final visual door check and included advice about tram drivers not relying solely on the door interlock system (doors closed indications) when deciding whether anything outside the tram is trapped in the doors.

Key facts and analysis

Identification of the immediate cause

33 The tram departed from the tram stop with a pushchair trapped in its doors.

Identification of causal factors

- 34 The incident occurred due to a combination of the following causal factors:
- the mother pushed the pushchair through the closing doors because travel officer 1 did not ensure that the whole family were able to get off the tram before the doors closed (paragraph 35);
 - the tram door system allowed the tram to depart while the rain cover remained trapped in the doors (paragraph 43); and
 - the driver was unaware of the pushchair, shown on a CCTV monitor in his cab, when deciding to start the tram (paragraph 54).

Each of these factors is now considered in turn.

The mother and the pushchair

35 The mother pushed the pushchair through the closing doors because travel officer 1 did not ensure that the whole family were able to get off the tram before the doors closed.

Role of travel officers

- 36 When checking that passengers have valid tickets or travel cards, travel officers work with at least one colleague. When travel officers identify a ticketing issue, Nottingham Trams requires them to ask passengers to leave the tram so that the issue could be dealt with privately, away from other people, and at a tram stop where a ticket machine is available. While travel officers do not perform safety critical tasks such as tram driving or deciding whether it is safe for a tram to depart, their actions can influence both passenger behaviour and tram safety.
- 37 When removing people from a tram to deal with a ticketing issue, travel officers are trained to make their colleague(s) aware of the situation so that all the travel officers on the tram get off together in order to assist each other if necessary. There is witness evidence that, when removing groups of people from a tram, travel officers were informally taught during practical training to use their feet to hold doors open until everyone in the group has got off. However, witness evidence indicates that travel officers 1 and 3 were not shown this during their training and Nottingham Trams stated that this technique does not form part of their formal training. Removing groups of people from trams is not covered in Nottingham Trams training material or other formal Nottingham Trams documentation (this is discussed further at paragraph 77).

Dealing with the family on the tram

- 38 As the tram approached Radford Road, travel officer 1 and the father were talking about the need to get off the tram to resolve the ticketing issue. Around this time the father told travel officer 1 he was travelling with his wife and child. This conversation continued when the tram arrived at Radford Road tram stop. The tram had been stationary for around five seconds before travel officer 1 and the father began to walk from the rear of the tram towards the set of double-doors nearest to where the mother was sitting. It was a further nine seconds before they reached the doors, passing the mother on their way. Travel officer 1 was aware that other people were traveling with the father because the father had told her he was travelling with his wife and child.
- 39 The door closure warnings started operating just as travel officer 1 and the father got off the tram. The mother was unaware that she would need to leave the tram at Radford Road until told by her husband as he moved towards the doors. The mother could not reach the doors in time to get off before they closed as she had to stand up with her child in her arms and manoeuvre the pushchair through the busy tram (figures 9c and 9d). Travel officer 1 did not take any action to ensure that the mother and child could safely leave the tram with the father.
- 40 CCTV at the tram stop shows that immediately after getting off the tram, travel officer 1 was engaged in conversation with the father, who was following behind her, and was looking to see that her colleagues had got off the tram to assist her, if needed. Travel officer 1 stated that she did not notice the door closure warning or notice that the mother had not got off the tram with the father.
- 41 The mother got to the doors just as they began to close, around three seconds after the door closure warning had begun. She attempted to leave the tram through the doors as they were closing because she was worried about being left on the tram without her husband. As the doors closed, and after pushing the pushchair between the closing doors, she withdrew her arm so as not to deliberately obstruct them or harm herself.
- 42 While the door closure warning is intended to influence passenger behaviour so that they do not get on or off as the doors close, RSSB³ research project T1102⁴ found that train passengers are not consistent in their understanding of door closure warning alarms, and that some passengers do not perceive the door close alarm as indicating that they should 'stand back'. However, in the situation at Radford Road, the mother was focused on trying to catch up with her husband and stated that she did not notice the alarm.

Detecting objects trapped in tram doors

43 The tram door system allowed the tram to depart while the rain cover remained trapped in the doors.

- 44 This causal factor arose due to a combination of the following:
- a. the door system did not detect the presence of the pushchair rain cover (paragraphs 45 to 47); and
 - b. the trapped pushchair could not be pulled free (paragraphs 48 to 53).

³ RSSB is 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'.

⁴ Available from www.sparkrail.org.

- 45 The door system fitted to the Citadis trams is designed to detect objects that are 10 mm or thicker⁵ (the visual check needed for thinner objects is discussed at paragraphs 58 to 61). This is one of the obstruction identification options permitted by BS EN 14752⁶. When objects 10 mm or thicker are detected by the door system, the doors reopen and will try to reclose up to three times, after which the doors will remain open until the driver has established the reason for them being unable to close. The tram motors will not be able to apply traction power to move the tram unless the detection system deems the doors fully closed and locked (paragraph 9).
- 46 The part of the rain cover that became trapped in the doors was 6 mm thick (ie less than the 10 mm specified in BS EN 14752 to be detected by the obstacle detection system). Testing by the RAIB after the incident showed that the door system was able to detect an object 10 mm thick but was not able to detect the pushchair's rain cover.
- 47 Since the rain cover was not detected by the obstacle detection system because it was less than 10 mm thick, the driver was able to apply traction power to move the tram in this incident.
- 48 Travel officer 1 made a grab for the trapped pushchair as the tram began to move but was not able to pull it free. Tram stop CCTV shows that she managed to get hold of one of the pushchair's handles but was not able to pull hard enough to release the pushchair. She was pulling it towards the rear of the tram at an angle of about 45° (figure 11).



Figure 11: Travel officer 1 pulling pushchair (tram stop CCTV courtesy of Nottingham Trams)

⁵ The requirement is to detect a 10 mm x 100 mm plate inserted with the 10 mm dimension between the doors.

⁶ British Standard BS EN 14752: Railway applications — bodyside entrance systems. This standard is the UK's implementation of European standard EN 14752, issued in 2005 and reissued in 2015. It specifies the minimum requirements for the construction and operation of railway passenger access doors fitted to trains and trams.

- 49 BS EN 14752 does not specify a maximum pull out force for trapped objects for door obstacle detection systems such as that on the Citadis tram.
- 50 Testing by the RAIB after the incident found that a force of about 160 N (equivalent to a weight of 16 kg) was needed to pull the trapped rain cover free from the doors if pulled at an angle of 90° relative to the tram doors. If pulled at an angle of 45° (the approximate angle travel officer 1 was pulling at) the rain cover split apart before it could be pulled free. The force measured at this point was 285 N (equivalent to a weight of 29 kg).
- 51 The RAIB considered the measured forces in the context of the requirements for another type of door detection system permitted by British Standard BS EN 14752. These requirements apply to doors which are not required to detect objects unless they are at least 30 mm thick (paragraph 45). In these circumstances a maximum extraction force of 150 N (equivalent to a weight of 15 kg) is specified when pulled at an angle of 90° relative to the door, slightly less than the 160 N (16 kg) force observed during RAIB testing.
- 52 The force required to pull the rain cover free was affected by the shape of the rubber seals fitted to the edges of the doors and the high level of friction between the rubber door seals and the plastic rain cover. The seal shape (figure 12) is intended to make a water tight seal between the door edges, but the shape of the seal edges means that thin flexible objects can be extremely difficult to pull free.

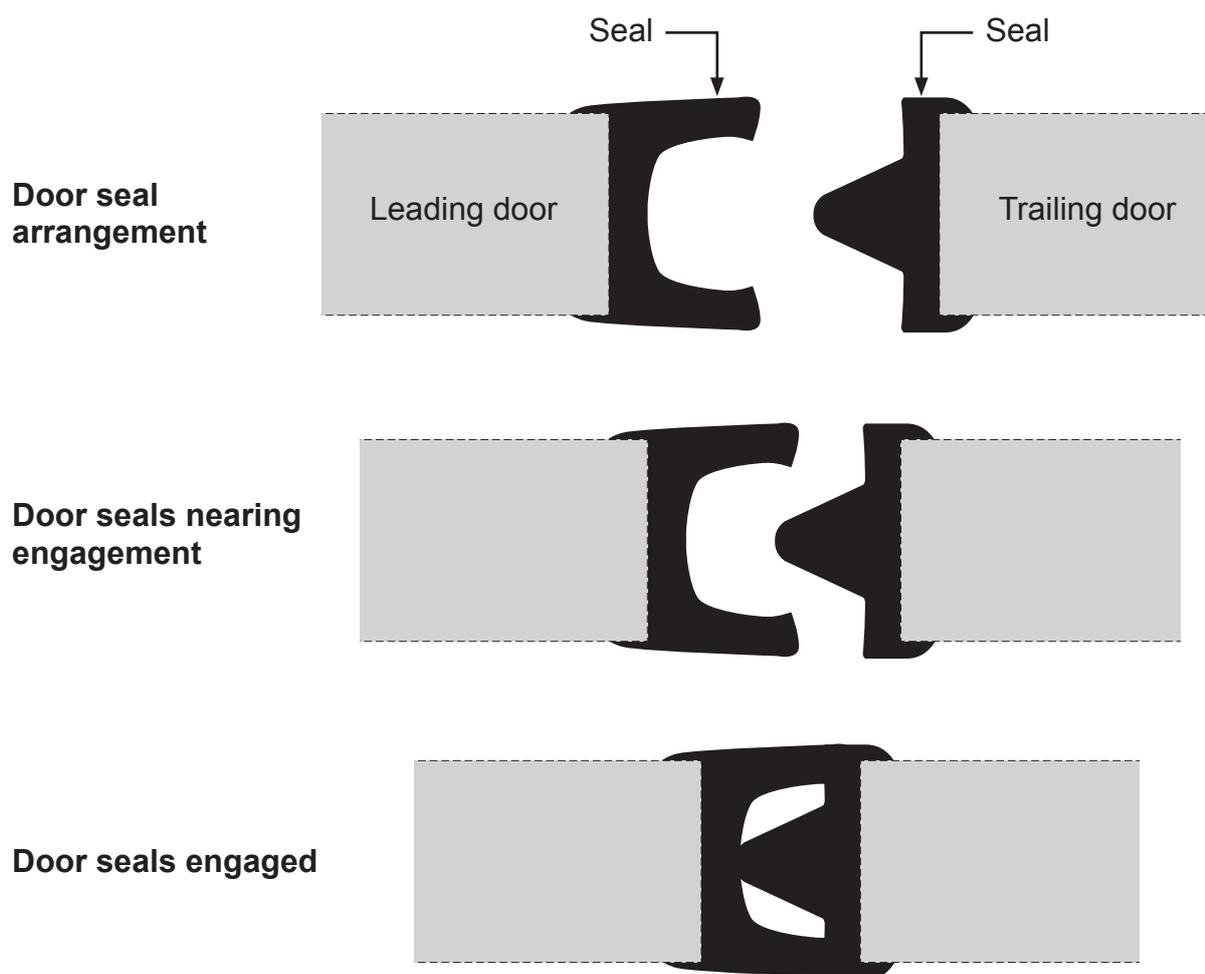


Figure 12: Door seals fitted to Nottingham Trams' fleet of Citadis trams (leading and trailing refer to direction of travel at time of incident)

- 53 In addition to the gripping effect of the door seals, it is possible that one of the securing loops (designed to keep the rain cover closed when it was not needed) was trapped on the inside face of the doors (figure 13). During two RAIB tests with the securing loop trapped inside the tram doors, the rain cover split apart and could not be pulled free in one piece. The pull forces, measured at right-angles to the doors immediately before the rain cover split apart, were 264 N (about 27 kg) and 289 N (about 29 kg).



Figure 13: Securing loop trapped inside tram doors during RAIB testing (leading and trailing refer to direction of travel at time of incident)

Driver awareness

- 54 **The driver was unaware of the pushchair, shown on a CCTV monitor in his cab, when deciding to start the tram.**
- 55 This causal factor arose due to a combination of the following:
- the driver did not see that the pushchair, shown on a CCTV monitor in his cab, was in an unsafe position (paragraphs 58 to 61);
 - the travel officers were aware that the pushchair was trapped but their actions did not prevent the tram departing and travelling to the next tram stop (paragraphs 62 to 64); and
 - the tram's CCTV coverage had been modified in a way that reduced the likelihood of the driver seeing the pushchair (paragraph 65).

- 56 The tram driver decided to close the tram doors at Radford Road tram stop when it appeared that people had stopped getting off and on the tram. Travel officer 1, the family, and the pushchair were still on the tram and so not visible to the driver (figure 14).



Figure 14: Tram stop when driver closed the tram doors (tram stop CCTV courtesy of Nottingham Trams)

- 57 When the doors were detected closed and locked, the image on the right-hand monitor in the driving cab immediately changed from the rear CCTV on the tram stop (left) side of the tram, to the right-hand 'wing mirror' view (paragraph 14). The pushchair, trapped in the doors near the rear of the tram, was now only visible in the left-hand monitor. In this view the pushchair was near the far end of the tram and was small in size relative to the overall size of the image (figure 15).



Figure 15: Driver's view of the side of the tram when doors detected closed and locked (tram CCTV courtesy of Nottingham Trams Ltd)

- 58 It is uncertain whether the driver looked at the left-hand monitor after the doors were detected closed and locked and before starting the tram. He stated that he normally did so and the absence of a specific recollection is unsurprising given how often he departed from tram stops. It is possible that the driver glanced at the platform side monitor but without the conscious attention needed to see the pushchair.
- 59 A glance at the left-hand monitor would be consistent with CCTV timings which show that the tram moved off around three seconds after the doors closed (part of this time is accounted for by the period of around two seconds between the driver selecting power and the tram moving off). During this time the driver was also required to check in the right-hand monitor that no vehicles were overtaking the tram, and look ahead to make sure the road was clear for the tram to move off.
- 60 The driver stated that he was not aware that thin objects could be trapped, but not detected by the door system. It is therefore possible that the driver's use of the CCTV to check the tram doors was influenced by his stated belief that he could rely on doors closed indications to confirm that nothing was trapped in the doors and that the tram was 'good to go'. These indications were the green light on the driving control panel, an audible chime, and a graphical display (paragraph 10).
- 61 Nottingham Trams stated that drivers can also use the internal rear view mirror to look at passenger doorways. However, on this occasion the tram was too busy for the driver to have seen very far back and the pushchair was outside the tram, except for part of the plastic rain cover.

Stopping the tram from departing

- 62 While the driver was preparing to drive away from the tram stop, after the doors had been detected closed and locked, travel officer 3 noticed the pushchair trapped in the tram doors. He immediately turned to face the front of the tram and waved both arms above his head to try and get the driver's attention. Travel officer 2 raised an arm above her head.
- 63 The driver was not aware of the travel officers' hand signals to stop the tram leaving (figure 10), almost certainly because he was focused on looking ahead and at the right-hand monitor to see if any vehicles were overtaking the tram.
- 64 Although trained in making radio emergency calls on their hand-held radios, the travel officers did not do so as the tram drove off along Radford Road. They stated that this was because they were relieved that there was not a child in the pushchair and they knew that the next tram stop was close by. They had never experienced such an incident before and did not consider the hazard that the pushchair presented (eg striking a cyclist or pedestrian). How travel officers are trained to deal with an emergency is discussed at paragraph 77.

CCTV design

- 65 The Citadis tram CCTV arrangements initially proposed by Alstom (the tram manufacturer) were modified in a way which had the potential to increase trap and drag risk. There is no evidence that Nottingham Trams appreciated or considered the safety effect of the modifications on trap and drag risk.

66 The original design of the Citadis tram offered to Nottingham Trams by Alstom included a CCTV system in which the CCTV views from the front and back platform-side cameras were enabled at a tram stop and remained enabled until the tram had moved around 30 metres (around the length of the tram). At this point the rear platform-side CCTV view switched to the non-platform side front CCTV camera view, thus presenting the driver with the ‘wing mirror’ view. However, because the trams were designed without traditional wing mirrors, it was identified that this configuration would not be compliant with road vehicle legislation and the requirements of Office of Rail and Road (ORR). These requirements were given in clause 275 of the ORR’s Railway Safety Publication 2 ‘guidance on tramways’ which stated:

‘Except on trams used solely on off-street tramways, mirrors or other devices should be provided to give the tram driver a rearward facing view along both body sides when the tram is in motion . . . ’

67 In order to comply with this requirement, Nottingham Trams proposed a modification to the CCTV which meant that, immediately the doors were closed and locked, the CCTV system would automatically switch to the wing mirror view. As a consequence, the platform-side CCTV view from the rear camera would not be available to the driver at the point when a final visual door check should be completed.

68 In accordance with Nottingham Trams’ process for managing change, a change proposal was submitted to Alstom on 20 March 2014. The proposal form included a check list that identified a number of system interfaces that could be affected by proposed changes. Of note is that ‘safety’ was included in this list, but was not identified as affected by the proposed CCTV change. Following a review of the proposed change by Alstom and by an independent competent person⁷, it was approved on 22 March 2014.

69 Although engineering risk assessments were undertaken, Nottingham Trams has stated that there was no assessment of possible effects on tram driver behaviour because the modification meant that the Citadis tram CCTV operated in the same way as the Incentro trams which had been in use on the Nottingham tramway since it opened in 2004. Nottingham Trams has been unable to find any evidence of an Incentro tram risk assessment relating to this CCTV arrangement.

70 This change to CCTV arrangements had four adverse effects. The first three (a, b and c) are possible influences on the incident at Radford Road. All four (a to d) affect both Citadis and Incentro tram operations in Nottingham:

- a. It is more likely that the driver would have noticed the pushchair if the rear CCTV camera view remained visible on his right-hand cab monitor when he was required to undertake the final visual door check. This was because the pushchair was trapped in one of the situations where the rear camera gives a better view than the front camera. In this instance, the pushchair appeared larger in the image from the rear camera than the image from the front camera (figures 15 and 16)⁸.

⁷ A person with the skills, knowledge, experience and resources to undertake an independent safety verification as required by the Railways and Other Guided Transport Systems (Safety) Regulations (2006).

⁸ The RAIB is aware of another UK tramway operator whose trams’ CCTV system (a different type of tram to the one involved in this incident) allows the driver to keep the rear camera view until the driver has completed the final visual door check before starting the tram.



Figure 16: Driver's view of push chair if rear CCTV camera view available after doors closed and locked (tram CCTV courtesy of Nottingham Trams Ltd)

- b. Changing CCTV views just before the final visual door check has the potential to divert a tram driver's attention to road traffic conditions before completing this check. It is possible that this occurred during the Radford Road incident.
- c. Loss of the rear CCTV images before completing the final visual door check is a possible influence on the importance attached to this check both by the driver at Radford Road and by all drivers when departing from tram stops. Loss of the better view of parts of the tram implies that the subsequent check is of relatively low importance⁹.
- d. Although not an influence on the incident at Radford Road, the RAIB observes that the CCTV modification also prevented drivers carrying out a final visual door check of some doors (paragraph 91).

Identification of underlying factors

Organisational understanding

71 Nottingham Trams had neither fully understood the risk of trap and drag incidents, nor put in place suitable mitigation measures.

Risk Assessment

72 The RAIB reviewed the mitigation given in Nottingham Trams' risk assessment of door related hazards at tram stops. The relevant extract of the Nottingham Tram risk assessment, dated 5 May 2017, is given at Appendix C. The hazards and mitigations relating to door hazards at tram stops, together with the results of the RAIB review, are given in table 1. Taken overall, this review shows that Nottingham Trams' risk assessment process lacked the depth needed for effective understanding of the risk and was therefore poorly suited to the identification of mitigation measures.

⁹ Woods, D.D. & Sarter, N.B. (2010). Capturing the dynamics of attention control from individual to distributed systems: the shape of models to come. *Theoretical Issues in Ergonomics Science*, 11(1-2), 7-28.

Hazards identified by Nottingham Trams	Mitigations identified by Nottingham Trams	Issues identified by the RAIB
Doors close with excessive speed or force	Line of sight driving	This mitigation measure is not relevant to the hazard. Including detail of mitigations would have shown that it is not relevant.
	Nottingham Trams procedure for tram driving outside depot	This mitigation measure is not relevant to the hazard so previous comment applies.
Passenger caught in door	System design – closure detectors	Inability to detect thin objects (paragraph 45) not recorded as a risk factor, and so is not allowed for in the risk assessment.
	System design – cab CCTV	Impacts of changing the CCTV system (paragraph 70) not recorded as risk factors, and so not allowed for in the risk assessment. Verification that all relevant parts of doors can be seen by CCTV is not recorded. Inclusion of this detail should have revealed that this was not possible on Citadis or Incentro trams (paragraph 91).
	Nottingham Trams training – depot, off and on street	Lack of detail of the type of training delivered, and the key messages trained is missing from the risk assessment. It is possible that including additional detail could have revealed that the inability of door closure system to detect thin objects was not effectively covered by training (a possible influence on the attention applied by drivers when doing final visual door checks, paragraphs 60, 75 and 76).
	Nottingham Trams maintenance	Maintenance is an Alstom responsibility (Alstom's maintenance risk assessments have not been reviewed by the RAIB because the door system operated as designed).
Passenger clothing caught in door	System design	Lack of detail on the operation of the door control system. The comment above on closure detectors also applies to this stated hazard.
	CCTV	The comments above on CCTV features also apply to this stated mitigation.
	Nottingham Trams training – depot, off and on street	The comments above on training also apply to this hazard.
	Alstom maintenance	Alstom's maintenance risk assessments have not been reviewed by the RAIB because the door system operated as designed.

Table 1: RAIB review of hazards and mitigations in Nottingham Trams' tram stop risk assessment

- 73 In addition to noting specific issues in the risk assessment document, the RAIB noted inconsistencies. For example, ‘training’ is given as mitigation for both the ‘caught in door’ hazards shown on table 1, but the corresponding on-going competency management is not mentioned. In contrast, competency management was included by Nottingham Trams when considering mitigations for other hazards in the risk assessment.
- 74 It is possible that risk would have been better understood had Nottingham Trams given greater consideration to previous similar events. Although Nottingham Trams is only aware of one relatively minor similar incident on its network (paragraph 95), the RAIB has published several reports and safety digests relating to trap and drag incidents in other parts of the rail industry (paragraph 96). Nottingham Trams’ response to one of these events is described at paragraph 104.

Object detection and final visual door check

- 75 The driver stated that he was unaware that small objects could be trapped when tram doors were detected closed and locked (paragraph 60). This belief was also apparent in evidence from a driver trainer and a driver manager at Nottingham Trams. The seniority and roles of these staff indicates a high probability that many other Nottingham Tram drivers shared this belief. The RAIB has investigated accidents and incidents on other parts of the UK rail industry where this belief has led staff to rely on the interlock system [doors closed indications] instead of undertaking a full final visual door safety check (paragraph 96).
- 76 There is no direct evidence that the tram driver involved in the Radford Road incident deliberately omitted the final visual door safety check. However, it is possible that his lack of understanding about trapped object detection affected his actions. The attention directed by people towards information in a task is sometimes dependent on their understanding of its importance (see paragraph 70(c)). It is therefore possible that the driver’s belief that trapped objects would be detected by the interlock system adversely influenced the attention with which he checked the CCTV monitor before departing from the tram stop.

Training

77 Nottingham Trams’ training of travel officers was inadequate.

- 78 Inadequate training of travel officers was apparent in two aspects of the Radford Road incident:
- the actions of travel officer 1 when removing the family (paragraphs 38 to 42); and
 - the actions of the travel officers when responding to the pushchair being dragged away from Radford Road tram stop (paragraph 62 to 64).
- 79 Nottingham Trams had no formalised process for removing groups of passengers from a tram. An unofficial method taught to some staff was for travel officers to use their feet to keep tram doors open. Witness evidence indicates that this was not taught to travel officer 1, and Nottingham Trams has stated this was not an approved procedure. Witness evidence also suggests that objects being trapped in doors, and the risk of people being dragged along by a departing tram, was not discussed during travel officer 1’s training.

- 80 An effective risk assessment should have identified the importance of travel officers understanding both the risk associated with passenger doors, and the way in which this should influence their actions. A similar outcome would be expected from a formal training needs analysis for the travel officer tasks. However, there was no formal training needs analysis. If the risk had been recognised, training should have followed and could have led travel officer 1 giving greater attention to making sure the family got off the tram together, and safely.

Emergency situation training

- 81 It is also possible that a greater depth of risk assessment and/or a training needs analysis would have identified the need to give travel officers guidance about when to apply emergency procedures, such as stopping a tram that is in an unsafe condition. In the Radford Road incident, after their actions to stop the tram departing were unsuccessful, none of the travel officers considered making an emergency call to Nottingham Trams' control room as they did not foresee that the trapped pushchair had the potential to cause injury to pedestrians and other road users.
- 82 During their training travel officers are taught how to make an emergency call using the radios they carry with them when on duty. This training covers how to operate the radio, the process of making an emergency call, including use of the phonetic alphabet, and the steps to take to make an effective emergency call. The travel officer training does not cover when an emergency call should be made, for example, in circumstances like those at Radford Road where a departing tram with something hanging outside, was a potential hazard to pedestrians and other road users.

Factors affecting the severity of consequences

83 The driver did not notice that the pushchair, shown on the left-hand CCTV monitor in his cab, was in an unsafe position when driving the tram to the next tram stop.

- 84 It is uncertain why the driver did not see that the pushchair was attached to the tram while travelling towards the next tram stop. It is possible that this was because, between the tram stops, the road was busy with vehicles and pedestrians so it is highly likely that the driver's focus was mainly on the road ahead.
- 85 Although the Highway Code¹⁰ requires drivers to use mirrors frequently so that they know what is to each side of their vehicle, identifying the pushchair, visible only as a small object in his left-hand monitor (figure 15), would possibly have required greater attention than was appropriate on a busy road.

¹⁰ Available at www.gov.uk.

86 Operation of a passenger alarm in the tram did not result in the tram being stopped.

- 87 About six seconds after the tram departed from Radford Road, CCTV on the tram shows the mother operating the emergency help point button located at the doorway. Help point buttons are intended to allow passengers to talk to the tram driver. The mother stated that she tried to talk to the driver but got no answer, and that during the journey to the next tram stop, she tried to talk to the driver several times.
- 88 The driver stated that he returned the mother's first emergency help point call, but got no answer, although he could hear voices in the background. He then switched on the tram's CCTV image to show an internal camera view of the doorway where the emergency help point had been operated (these images are displayed on the driver graphical information display). The driver stated that what he heard and saw led him to believe a heated discussion was taking place.
- 89 Nottingham Trams stated that drivers are trained not to intervene in circumstances where there is an on-tram incident such as an argument, instead drivers are required to call Nottingham Trams' control room to request assistance. The driver did not report an argument on arrival at Hyson Green Market because he was then aware of the actual circumstances of the pushchair being trapped in the tram's doors.
- 90 The RAIB's post-incident study of the tram CCTV images viewed by the driver showed that the passenger looked distressed but was not arguing with anyone. The RAIB also reviewed the audio recording linked to the driver communication system. Although a distressed passenger could be heard talking in the background, the nature of the distress is unclear.

Observation

CCTV blind spot

91 The Citadis and Incentro trams bodyside cameras do not provide a full view of the nearest door, so do not allow drivers to check for objects trapped in the lower part of the forward most door before departing from a tram stop.

- 92 The field of view of the CCTV cameras fitted to the outside of the Citadis and Incentro trams does not cover the full height of the nearest door. RAIB testing found that these cameras did not show the lowest 1520 mm of the closed edge of the nearest door on the Citadis trams, and the lowest 880 mm of the closed edge of the nearest door on the Incentro trams (figure 17).
- 93 This means that a small person or an object could be trapped in the front door of a tram and not be seen by the front CCTV camera, the only camera view available when the driver is required to carry out the final visual door check after the doors are detected closed and locked.

- 94 The position of the front CCTV camera relative to the front door differed between the Incentro and Citadis trams, and the doors on the two types of tram open in opposite directions (figures 17a and 17b). This means that coverage of the front door by the CCTV systems was likely to be different so it was inappropriate to rely on an Incentro risk assessment when modifying the Citadis CCTV arrangement (paragraph 69).

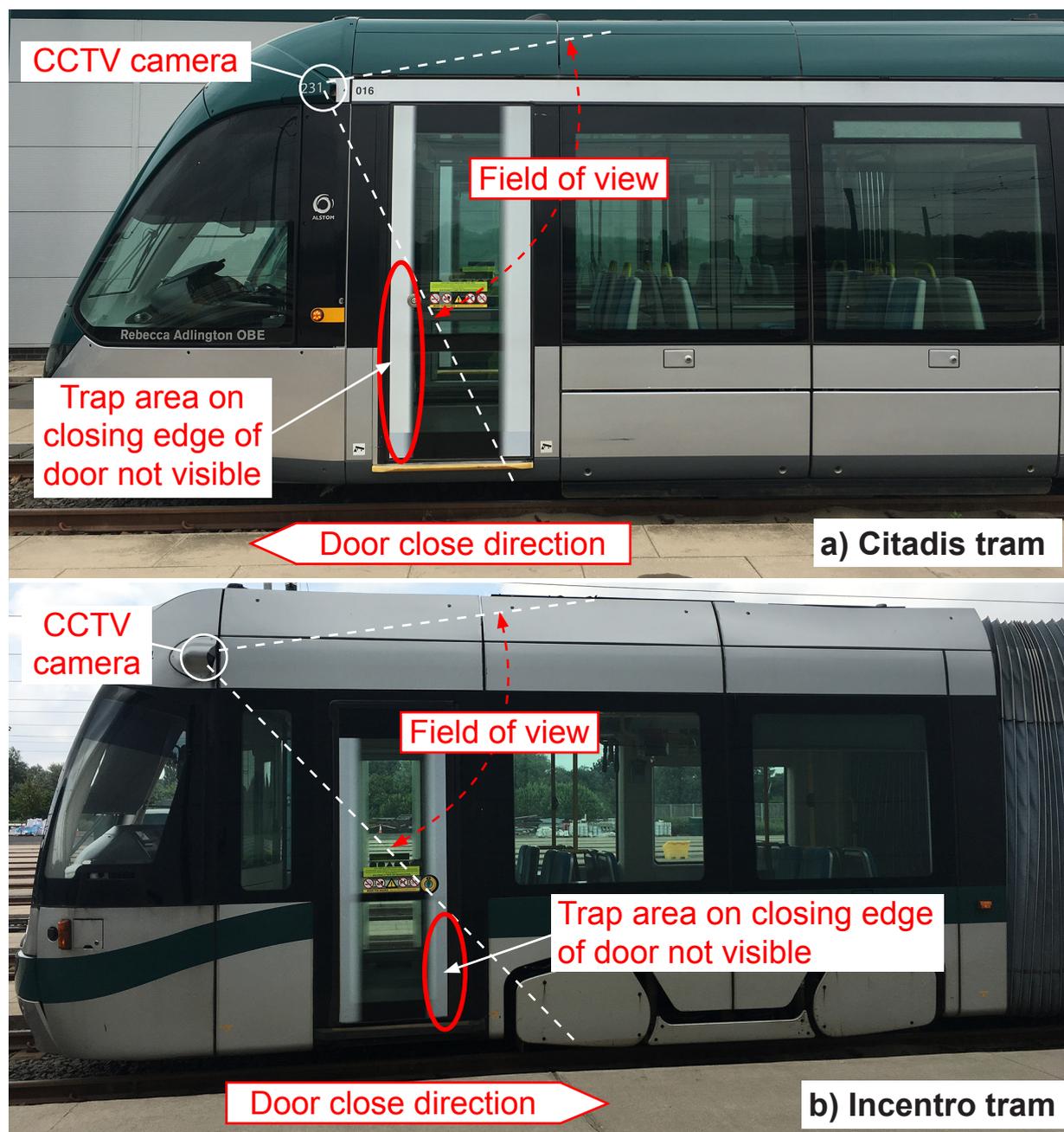


Figure 17: Door trap areas not covered by leading CCTV cameras: a) Citadis tram; b) Incentro tram

Previous occurrences of a similar character

- 95 Nottingham Trams stated that its only record of an event similar to the Radford Road incident occurred in February 2015 when a passenger's glove became trapped in the closed and locked doors of a Citadis tram at Old Market Square. The glove involved in the February 2015 incident was too thin to be detected by the door obstacle detection system and was not noticed by the tram driver. Nottingham Trams stated that it briefed its drivers about this incident.
- 96 The RAIB has investigated a number of accidents in which passengers were trapped in train or tram doors and then dragged. The following accidents included the absence of a final visual door check and/or reliance on the door interlock system as factors:
- At Wellesley Road, Croydon on 15 June 2007 ([RAIB report 40/2007¹¹](#)), a passenger was dragged after their hand or clothing became trapped in the closed and locked doors of a departing tram. The investigation found that the door detection system did not detect the passenger's trapped hand or clothing in the closed and locked doors, and that neither the trainee nor instructor driver completed a final visual door check.
 - At Tooting Broadway station, London, on 1 November 2007 ([RAIB report 17/2008](#)), a passenger was dragged a short distance after their coat became trapped in the closed and locked doors of a departing underground train. The investigation found that the train's operator (driver) did not observe the CCTV images, used to check whether passengers are at risk from trap and drag events, after initiating door closure.
 - At King's Cross station, London on 10 October 2011 ([RAIB report 09/2012](#)), a passenger was dragged after a member of staff on the platform did not fully comply with a requirement to check that nobody was trapped in the train doors (a final visual door check). The investigation also found that the design of the train's door seals made it difficult for the passenger's hand to be pulled free from between the closed doors.
 - At Newcastle Central station on 5 June 2013 ([RAIB report 19/2014](#)), a passenger was dragged when their wrist became trapped in the closed and locked doors of a departing train. The investigation found that the door detection system did not detect the passenger's trapped wrist in the closed and locked doors and that the train's conductor (guard) did not complete a final visual door check.
 - At West Wickham on 10 April 2015 ([RAIB report 03/2016](#)), a passenger was dragged when a train departed while a buckle or twisted strap on their backpack was trapped inside the train and could not be pulled free from between the closed and locked doors. The train's driver did not complete an effective final door visual check, possibly because he was reassured by the illuminated door interlock light that is was safe for the train to start.

¹¹ RAIB reports are available from www.gov.uk/raib.

- At Hayes & Harlington station on 25 July 2015 ([RAIB report 12/2016](#)), a passenger was dragged by a train when the train driver did not complete an effective final door visual check and so did not identify that the passenger's hand was trapped in the closed and locked doors. The investigation found that the door detection system did not detect the passenger's hand in the closed doors and that the train driver and other train company staff believed that the door interlock system would detect the presence of an object such as a hand.
- At Bushey station on 26 March 2018 a passenger was dragged when their arm became trapped in the closed and locked doors of a departing train ([RAIB safety digest 07/2018](#)). The guard did not complete an effective final door visual check and incorrectly believed that he could rely on the door interlock (object detection system) to determine whether anyone was trapped in closed doors.
- At Bury station on the Manchester Metrolink tramway system on 30 May 2018, a passenger was dragged when their hand became trapped in the closed and locked doors. The tram stopped having travelled for about 15 metres ([RAIB safety digest 08/2018](#)). The tram driver had relied on the doors closed indication (interlock) and was not aware that small objects could be trapped but undetected in the tram's doors.

Summary of conclusions

Immediate cause

97 The tram departed from the tram stop with a pushchair trapped in its doors (paragraph 33).

Causal factors

98 The causal factors were:

- a. The mother pushed the pushchair through the closing doors because travel officer 1 did not ensure that the whole family were able to get off the tram before the doors closed (paragraph 35, **Recommendations 1 and 2**).
- b. The tram door system allowed the tram to depart while the rain cover remained trapped in the doors (paragraph 43, **Recommendation 2**). This causal factor arose due to a combination of the following:
 - the door system did not detect the presence of the pushchair rain cover (paragraphs 45 and 46); and
 - the trapped pushchair could not be pulled free (paragraphs 48 to 53).
- c. The driver was unaware of the pushchair, shown on a CCTV monitor in his cab, when deciding to start the tram (paragraph 54). This causal factor arose due to a combination of the following:
 - the driver did not see that the pushchair, shown on a CCTV monitor in his cab, was in an unsafe position (paragraph 58, **Recommendation 1, learning point 1**);
 - the travel officers were aware that the pushchair was trapped but their actions did not prevent the tram departing and travelling to the next tram stop (paragraph 62); and
 - the tram's CCTV coverage had been modified in a way that reduced the likelihood of the driver seeing the pushchair (paragraph 65).

Underlying factors

99 The underlying factors were:

- a. Nottingham Trams had neither fully understood the risk of trap and drag incidents, nor put in place suitable mitigation measures (paragraph 71, **Recommendations 1 and 2**).
- b. Nottingham Trams' training of travel officers was inadequate (paragraph 77, **Recommendation 1**) as shown by:
 - the actions of travel officer 1 when removing the family (paragraphs 38 to 42); and
 - the actions of the travel officers when responding to the pushchair being dragged away from Radford Road tram stop (paragraphs 77 to 82).

Factors affecting the severity of consequences

100 Factors that exacerbated the consequences of the event were as follows:

- a. the driver did not notice that the pushchair, shown on the left-hand CCTV monitor in his cab, was in an unsafe position when driving the tram to the next tram stop (paragraphs 54 to 61, no recommendation); and
- b. operation of a passenger alarm in the tram did not result in the tram being stopped (paragraph 86 to 90, no recommendation).

Additional observation

101 The Citadis and Incentro trams bodyside cameras do not provide a full view of the nearest door, so do not allow drivers to check for objects trapped in the lower part of the forward most door before departing from a tram stop (paragraph 91, **Recommendations 1 and 2**).

Previous RAIB learning point relevant to this investigation

102 The following learning point¹², which was made by the RAIB as a result of a previous investigation, has relevance to this investigation.

[Accident at Hayes and Harlington on 25 July 2015, RAIB report 12/2016, Learning Point 1](#)

103 The RAIB report on an accident at Hayes and Harlington ([RAIB report 12/2016](#)) directly addressed inappropriate reliance on indications that doors were closed and locked (known as door interlock on the mainline railway). The relevant learning point¹³ read as follows:

On 30 November 2015, the RAIB issued Urgent Safety Advice to the railway industry regarding the importance of drivers undertaking the final safety check and not relying on the door interlock light as an indication that it is safe for their train to proceed. The RAIB wishes to emphasise the importance of this safety learning. It is important that train drivers are briefed that illumination of the door interlock light only means that the doors are confirmed as closed and locked, but does not provide confirmation that nothing is trapped in them. The briefing should place particular emphasis on the importance of monitoring doors during closure and the final safety check after interlock has been obtained.

104 Nottingham Trams stated it believed that this safety learning only applied to the mainline railway, and not to the Nottingham tramway as the report made no mention of trams.

105 In many incidents and accidents safety learning has wide applicability. Even in cases where recommendations are made to some parts of the rail industry, there can be useful safety learning for other parts of the rail industry, and tramways. The Radford Road incident involved inappropriate reliance on indications that the doors were closed and locked (reliance on the 'interlock light'), an issue previously identified in RAIB reports relating to mainline operations. The door control systems, and the associated human interaction with equipment, procedures and dynamically changing situations applies equally to operating a tram and a train.

¹² 'Learning points' are intended to disseminate safety learning that is not covered by a recommendation. They are included in a report when the RAIB wishes to reinforce the importance of compliance with existing safety arrangements.

¹³ The RAIB addresses recommendations to organisations with an evidenced link to the issues covered by the recommendations. The RAIB's Hayes & Harlington investigation did not justify a direct link to tramways.

Recommendations that are currently being implemented

[Accident at Sandilands junction, Croydon, on 9 November 2016, RAIB report 18/2017, Recommendations 1 and 2](#)

106 On 9 November 2016 a tram overturned on a bend at Sandilands junction on the Croydon tramway ([RAIB report 18/2017](#)). Seven people were killed and nineteen people were seriously injured. Although the causes of the Sandilands accident are not directly related to the Radford Road incident, one of the recommendations (Recommendation 1) made by the RAIB provides a forum at which the UK tram industry can benefit by sharing knowledge about safety issues including managing trap-and-drag risk. The recommendation stated:

ORR [Office of Rail and Road] should work with the UK tram industry to develop a body to enable more effective UK-wide cooperation on matters related to safety, and the development of common standards and good practice guidance....

107 The RAIB welcomes the cross-industry approach being taken to this recommendation as described by the ORR in its letter dated 6 April 2018 and copied to the RAIB:

'Following a meeting on 22 January 2018 the Light Rapid Transit Safety and Standards Board (LRTSSB) steering group was established. The LRTSSB steering group has taken ownership of Sandilands recommendations 1 to 8, and once formally established the aim of the LRTSSB will be to improve the management and collaboration of safety risk and to enable more effective industry cooperation'.

108 Recommendation 2 of the Sandilands report stated that:

UK tram operators, owners and infrastructure managers should jointly conduct a systematic review of operational risks and control measures associated with the design, maintenance and operation of tramways...[including]...safety learning from bus and train sectors that may be application to the design and operation of tramways.

109 The RAIB notes that work to implement the recommendations arising from the Sandilands accident could be used by Nottingham Trams when implementing the recommendations related to the Radford Road incident (paragraph 107 of this report).

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

- 110 Nottingham Trams report that travel officers have been briefed that, when they are taking a group of people off a tram, they are to walk behind the group to ensure that everyone has got off the tram before it departs. If necessary, travel officers have been briefed that they must talk to the driver using emergency help point buttons located at doorways if they need more time to get the group off the tram together.
- 111 In response to Sandilands Recommendation 1 (paragraph 107) Nottingham Trams reports that, together with the other UK tram operators, it is developing a safety risk model, similar to that used by the main line railway¹⁴, to better understand tramway risk.

¹⁴ Information about the mainline safety risk model is available from www.rssb.co.uk.

Recommendations and learning point

Recommendations

112 The following recommendations are made¹⁵:

1 *This recommendation is intended to reduce trap and drag risk.*

Nottingham Trams Limited should review and improve arrangements intended to manage the risk of trap and drag during tram dispatch on its network. The review should consider equipment, operating practices and the interaction between these. Areas in which improvements should be considered include:

- ensuring that tram drivers have the equipment needed for an effective final visual door check of all doors after interlock is achieved;
- CCTV modifications to ensure a good view during the final visual door check of all areas where items could be trapped in closed and locked doors;
- investigating possible door seal modifications to reduce the risk of trapping items and, if appropriate, developing a programme for installation of improved door seals (eg during planned major overhauls);
- the initial training, refresher training and monitoring needed to ensure that drivers comply with tram stop procedures and understand the importance of undertaking an effective visual check of all doors after interlock is achieved; and
- the initial training, refresher training and monitoring needed to ensure that travel officers:
 - apply appropriate procedures when removing passengers from trams;
 - understand trap and drag risk and how this affects their work; and
 - appreciate what should be considered as emergency situations and how they should respond to these.

This recommendation may apply to other tramways (paragraphs 98, 99 and 101).

¹⁵ Those identified in the recommendations have a general and ongoing obligation to comply with health and safety legislation, and need to take these recommendations into account in ensuring the safety of their employees and others.

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

- (a) ensure that recommendations are duly considered and where appropriate acted upon; and
- (b) report back to RAIB details of any implementation measures, or the reasons why no implementation measures are being taken.

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

- 2 *This recommendation is intended to increase Nottingham Trams' understanding of tram risk and the effectiveness of the mitigation measures on which it relies. It is possible that increased understanding of risk from low frequency, high consequence events could be assisted by Nottingham Trams working with the light rail industry body being set up in response to the RAIB's recommendation arising from the Sandilands accident (paragraph 107).*

Nottingham Trams Limited should review its risk assessment process with a view to:

- improving the means by which it considers learning from other parts of the tramway and railway industries;
- giving explicit and detailed consideration of the ways in which identified mitigation measures can fail, and the consequences when this happens; and
- effectively evaluating the safety impact of changes to design and/or operational procedures.

Nottingham Trams should then implement the identified changes and update its existing tram operation risk assessments in accordance with the enhanced procedures (paragraphs 98, 99 and 101).

Learning point

113 The RAIB has identified the following learning point¹⁶:

- 1 This incident emphasises the importance of tram drivers not relying on the tram's doors closed and locked indications (interlock systems) as an assurance that nothing is trapped in the doors. A thorough final visual door check (using CCTV if appropriate) is essential after obtaining doors closed and locked indications and before moving the tram to confirm that nothing outside the tram is trapped in the doors (paragraph 98). This learning was also contained in [RAIB Urgent Safety Advice 01/2018](#).

¹⁶ 'Learning points' are intended to disseminate safety learning that is not covered by a recommendation. They are included in a report when the 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.

Appendices

Appendix A - Glossary of abbreviations and acronyms

CCTV	Closed-circuit television system
LRTSSB	Light Rapid Transit Safety and Standards Board
ORR	Office of Rail and Road
RAIB	Rail Accident Investigation Branch
RSSB	Formerly, Rail Safety and Standards Board

Appendix B - Investigation details

The RAIB used the following sources of evidence in this investigation:

- information provided by witnesses;
- information taken from the on-tram data recorder (OTDR);
- CCTV recordings taken from Radford Road and Hyson Green tram stops and from the tram involved in the incident;
- photographs and measurements;
- a review of safety management documents, including training records;
- results of testing of the tram's doors and CCTV system; and
- a review of previous RAIB investigations that had relevance to this incident.

Appendix C - Nottingham Trams' tram stop risk assessment

Risk Assessment					RA-PS-Tram stop interface				
ID	Hazard consequences	Pre mitigation			Mitigations	Post mitigation			Residual hazards
		Severity	Probability	Class		Severity	Probability	Class	
1	Doors open wrong side at tram stop/Doors open at location other than tram stops – <i>Falling – Severe injuries/Death</i>	4	3	II	- Driver training/competence - Line-of-sight driving - NTL procedure tram driving outside of depot	4	2	II	
2	Doors close with excessive speed or force – <i>nips, injury</i>	2	2	II	- Line-of-sight driving - NTL procedure tram driving outside of depot	2	2	III	
3	Disembarking passengers – <i>Struck by tram – Severe injuries/Death</i>	4	2	II	- Line-of-sight driving - NT training – off and on street - NTL procedure tram driving outside of depot	4	1	III	
4	Passenger caught in door – <i>Entrapped, Falls – severe injury</i>	2	4	II	- System design – Closure detectors, Cab CCTV - NT training Depot, Off & On street - NT maintenance	2	3	II	
5	Passenger clothing caught in door – <i>Entrapped, Falls – severe injury/death</i>	3	3	II	- System design - CCTV - NT training Depot, Off & On street - Alstom maintenance	3	2	II	

I	Intolerable
II	Tolerable
III	Negligible

Appendix D - RAIB Urgent Safety Advice



Urgent Safety Advice 01/2018: Checking that tram doors are safe before departing from tram stops

Published 7 February 2018

1. Safety issue

Thin objects can remain trapped in tram doors after door interlock has been obtained and trams can then be driven away from a stop. Preventing objects and people being dragged in such circumstances depends on a visual check of the outside of the tram before it departs.

2. Safety advice

Tram operators should take urgent steps to confirm or ensure that tram drivers:

- perform a thorough check after obtaining door interlock and before moving the tram to confirm that nothing outside the tram is trapped in the doors;
- do not place sole reliance on the door interlock system when deciding whether anything outside the tram is trapped in the doors; and
- are provided with the means to achieve the above.

3. Issued to:

- UK tram operators

4. Background

At about 13:29 hrs on Friday 15 December 2017, an empty pushchair was dragged on the outside of a tram from Radford Road to Hyson Green Market tram stops after its plastic rain guard became trapped in the tram's closed doors. Nobody was injured during the incident.

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