

Rail Accident Report



**Signal passed at stop and near miss,
Deansgate-Castlefield tram stop, Manchester
17 May 2019**

This investigation was carried out in accordance with:

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

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Preface

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

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

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

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

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

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

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

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Summary

At around 17:19 hrs on 17 May 2019, a tram passed through the centre platform of Deansgate-Castlefield tram stop on the Manchester Metrolink system, without making its scheduled stop. The tram exited the platform at around 9 mph (14 km/h) and then passed a stop signal. This placed it in the path of a second tram, which was approaching a junction as part of a signalled movement. The driver of the second tram saw the first tram approaching and was able to stop in time to avoid a collision.

The incident occurred because the driver of the first tram did not stop at the platform or stop signal, due to a temporary loss of awareness. While some doubt remains as to the reason for this loss of awareness, RAIB considers that it was either the result of a medical event or the driver losing focus on the driving task. RAIB found that the driver had been involved in previous similar incidents but that the tramway operator, Keolis Amey Metrolink, had not adequately addressed his safety performance. RAIB also found that the driver's safety device on the tram did not detect or mitigate the driver's loss of awareness because it was not designed to do so.

The hazard of a driver losing awareness while operating a tram was not recognised by Thales when it risk assessed the new layout at the tram stop or by Transport for Greater Manchester when it approved the new layout for service. Keolis Amey Metrolink also did not recognise this hazard during its risk assessment of the new layout, although it did identify the hazard as part of a general risk assessment of tram driving tasks. Despite this, the associated risks were not effectively controlled.

RAIB has made three recommendations, all addressed to Keolis Amey Metrolink. The first recommendation concerns a review and updating of its strategy for managing the risk of trams passing signals at danger or stop. The other recommendations relate to factors that were not causal to the incident, but which address safety issues identified during the investigation. These are concerned with Keolis Amey Metrolink ensuring medical fitness requirements for drivers are based on an understanding of the risks of their activities, and that its fatigue risk management system meets with relevant industry guidance and best practice.

RAIB has also referred to two previous recommendations made in its report into the overturning of a tram at Sandilands junction, Croydon, on 9 November 2016. One of these previous recommendations was 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. The second was that UK tram operators, owners and infrastructure managers should work together to research and evaluate systems capable of reliably detecting driver attention state and initiating appropriate automatic responses if a low level of alertness is identified.

Introduction

Definitions

- 1 Metric units are used in this report except for tram speeds, which are given in miles per hour alongside the equivalent metric value.

The incident

Summary of the incident

- 2 At around 17:19 hrs on 17 May 2019, Metrolink tram 83 passed through the centre platform of Deansgate-Castlefield tram stop, Manchester, without making its scheduled stop (figure 1). The tram exited the platform at around 9 mph (14 km/h) and passed a signal showing a stop aspect.

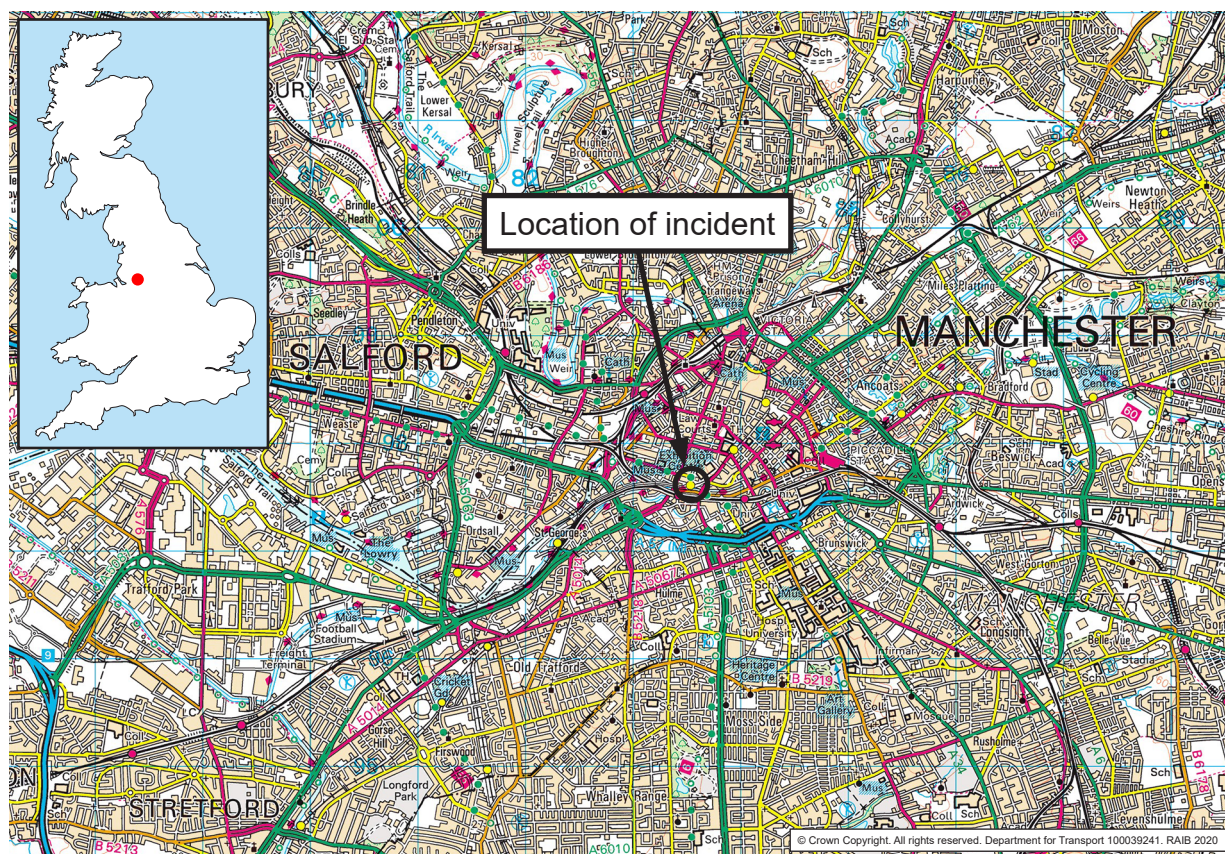


Figure 1: Extract from Ordnance Survey map showing location of incident

- 3 Tram 83 then entered the junction where the lines from the inbound and centre platforms join to form the single inbound line towards St Peter's Square tram stop. This placed it in conflict with Metrolink tram 38, which was approaching the same junction from the inbound platform, under a proceed signal. The driver of tram 38 glanced to his right as he neared the junction and saw tram 83 approaching. He was able to stop his vehicle in time to narrowly avoid a collision (figure 2).

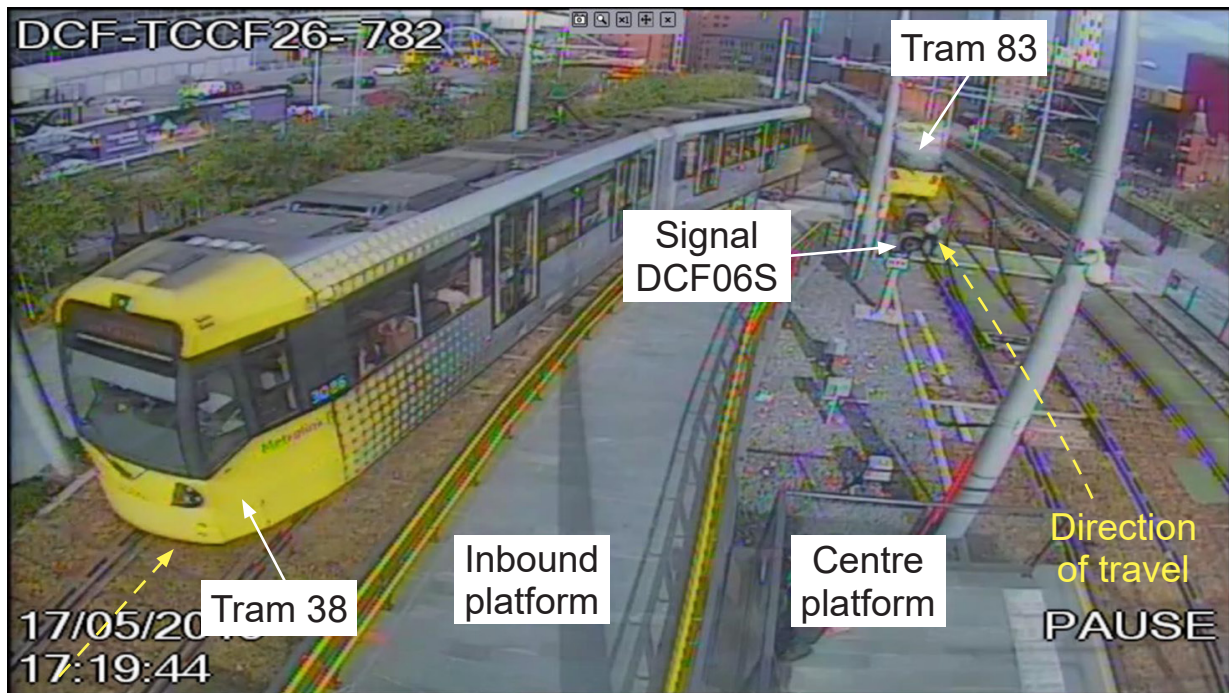


Figure 2: CCTV image from Deansgate-Castlefield tram stop, showing the incident (image courtesy of Keolis Amey Metrolink)

4 No one was injured and no tramway equipment was damaged during the incident.

Context

Location

5 Deansgate-Castlefield tram stop is located between Cornbrook tram stop (to the west) and St Peter's Square tram stop (to the north-east) (figure 3). The tramway at this location is 'off-street' which means that the alignment of the track is wholly separate from the highway. It is also elevated above the level of nearby streets.

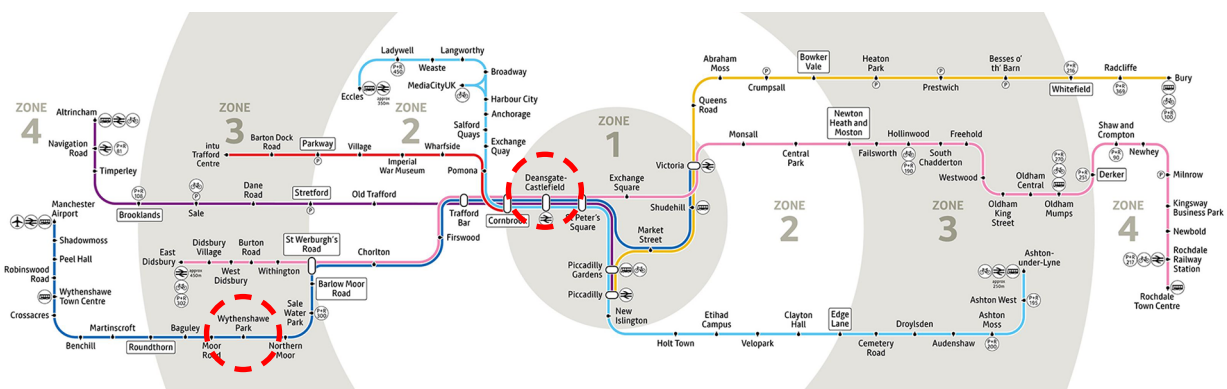


Figure 3: Manchester Metrolink system map, with the location of Deansgate-Castlefield and Wythenshawe Park tram stops highlighted (image courtesy of Transport for Greater Manchester)

- 6 The tram stop has three platforms, each of which can accommodate two trams. The inbound platform is used by trams travelling towards Manchester city centre from Cornbrook and the outbound platform by trams travelling away from the city. The centre platform was added in 2017 as part of the Deansgate-Castlefield remodelling programme. In normal service this platform is used by inbound trams, although it can be used by outbound trams during engineering work or degraded operations. The tram stop includes a pedestrian walkway at each end. This crosses the tram lines and allows pedestrian access to and from the platforms.

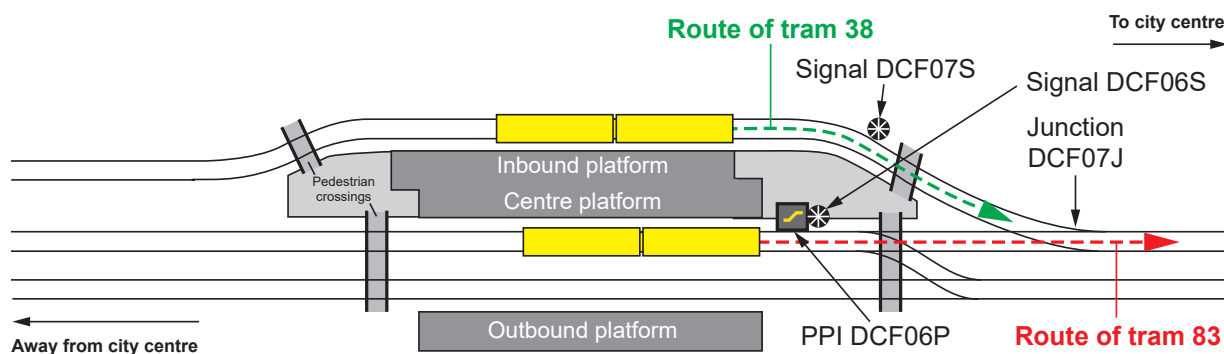


Figure 4: Layout of Deansgate-Castlefield tram stop (note some details have been removed for clarity)

- 7 The lines from the inbound and centre platforms converge at junction DCF07J. This is made up of a set of trailing points¹ located approximately 35 metres from the end of the centre platform. Trams leaving the centre platform must also pass over a set of facing points at junction DCF06J. This junction allows trams to pass between the inbound and outbound lines outside normal service patterns.
- 8 The route for inbound trams approaching Deansgate-Castlefield includes several visually distinctive trackside features. These include the Castlefield viaduct, which has a lattice girder structure, and a skew truss bridge. As inbound trams approach the girders on the viaduct, the speed limit reduces from 30 mph (48 km/h) to 25 mph (40 km/h). This steps down further to 15 mph (24 km/h) as the line divides into the routes towards the inbound and centre platforms and then to 10 mph (16 km/h) on the immediate approach to the platforms.
- 9 Manchester Metrolink's Tram Management System (TMS) controls signalling at Deansgate-Castlefield and its immediate approaches. It does this by locating trams via induction loops in the track and using control circuits to command signals and motorised points. TMS does not use the block signalling² principle and relies on line-of-sight to avoid collisions between trams and between trams and pedestrians. Industry guidance³ describes line-of-sight as a mode of operation where 'a tram should be able to stop, before a reasonably visible stationary obstruction ahead, from the intended speed of operation using the service brake'.

¹ A set of points where two routes converge in the normal direction of traffic.* This and other definitions marked with an asterisk have been taken from 'Ellis's British Railway Engineering Encyclopaedia' © Iain Ellis <http://iainellis.com/>.

² A method of managing the safe passage of trains along a railway by dividing a line up into block sections and only allowing one train to enter any block section at once.*

³ LRSSB 'Tramway Principles and Guidance', Issue 1 Revision 3, September 2019 <http://lrssb2018.wpengine.com/wp-content/uploads/2019/09/LRG-1.0-Tramway-Principles-and-Guidance-TPG-Final2.pdf> This replaced guidance published by UK Tram, the representative body for tramways and light rail systems in the UK, which contained the same definition.

- 10 Line-of-sight operation requires tram drivers to obey relevant signals. They must also check that any facing points⁴ are in the correct position for their intended route by checking the relevant points position indicator (PPI) and the physical position of the points before they pass over them. Line-of-sight is the predominant mode of operation for tramways in the UK.
- 11 TMS will normally route inbound trams approaching from Cornbrook into the inbound platform via a set of motorised points. A tram driver should not allow their tram to depart from the inbound platform until they receive a proceed aspect on DCF07S signal (figure 5). If the inbound platform is already occupied by two trams, TMS will route the next inbound tram into the centre platform instead. A tram should not depart from the centre platform until a proceed aspect is displayed on DCF06S signal and the PPI for junction DCF06J shows a left indication to indicate that it is set for trams to continue straight ahead on the inbound line (figure 6).



Figure 5: Signal DCF07S located beyond the inbound platform

- 12 Signals DCF07S and DCF06S maintain a stop aspect unless the routes they control are granted by TMS. The process of granting a route is started by a driver making a request using the 'Tram Ready to Start' (TRTS) button in the tram's cab. The request is then transmitted to the TMS system via the track induction loops. Before TMS grants a route and clears the associated departure signal, a conflict manager function ensures that no conditions exist which could make granting the route potentially dangerous.

⁴ A set of points where two or more routes diverge in the normal direction of travel.*

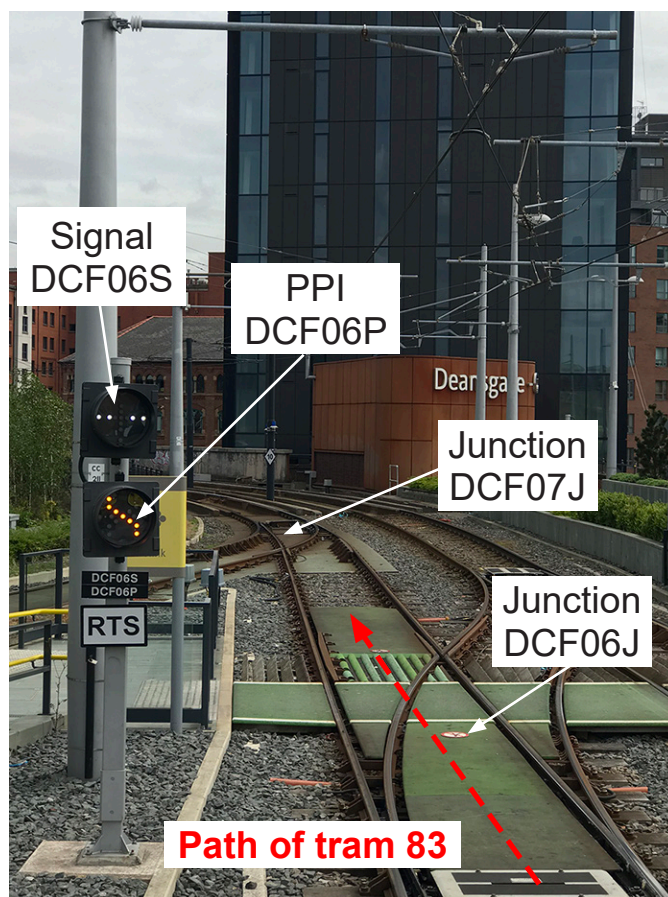


Figure 6: Signal DCF06S, PPI DCF06P and the junctions located beyond the centre platform

- 13 This conflict management process means that DCF07S and DCF06S should not show a proceed signal at the same time. Once a route has been granted by TMS, junction DCF07J will be reserved in the system until the departing tram has confirmed it is clear by passing a track induction loop located beyond the junction.

Organisations involved

- 14 Keolis Amey Metrolink (KAM) has been the franchisee responsible for the operation and maintenance of the Metrolink system since July 2017. It employs the drivers of both trams and is responsible for assessing the risks associated with tram driving and the operation of Deansgate-Castlefield tram stop.
- 15 Transport for Greater Manchester (TfGM) is the public body responsible for co-ordinating public transport in the Manchester area. TfGM is the owner of the Metrolink system. It was responsible for awarding the franchise to operate and maintain the system to KAM. TfGM was also responsible for awarding the contracts associated with the Deansgate-Castlefield remodelling project. As part of this programme, TfGM awarded a contract for modifying the signalling at the tram stop to Thales, which was already fitting TMS more widely across the network.
- 16 All parties freely co-operated with the investigation.

Trams involved

- 17 Tram 83 was the 16:27 hrs service from Manchester Airport to Victoria. It was formed of a single Bombardier M5000 type tram, vehicle number 3117. This type of tram consists of two end cars fitted with a driving cab, joined by a central articulation unit. There were estimated to be between 50 and 75 passengers on board the tram at the time of the incident.
- 18 M5000 type trams are controlled by drivers using a Traction/Brake Controller (TBC) on the driver's left-hand side. Pushing the TBC from a central position forward into the DRIVE position engages the traction system and accelerates the tram. Moving the TBC further forwards through the DRIVE position increases the rate of acceleration. This is expressed in terms of percentage, with +100% being the highest acceleration rate. Pulling the TBC rearwards from the central COAST position into the BRAKE position applies the tram's service brakes.⁵ Moving the TBC further rearwards increases braking effort until 'full-service braking' is achieved at -100%. Moving the TBC further rearwards from full service braking through a notch will place it into the HAZARD BRAKE position. This will initiate hazard braking.⁶ If the TBC is left in the COAST position, then the tram will free-wheel with no traction or braking demand.
- 19 Tram 83 continued in service after the incident was reported, and no post-incident inspection or testing of the tram's systems was undertaken. No allegations were made after the incident concerning the performance of the tram. There is also evidence from the tram's On Tram Data Recorder (OTDR) and maintenance records which suggests that relevant systems on the tram were functioning correctly. Therefore, RAIB has concluded that the performance of the tram and its systems played no part in the incident.

Staff involved

- 20 The driver of tram 83 was 62 years old. He started training as a tram driver in July 2017 and passed his final practical tram driving test in October 2017. Prior to the incident he had been involved in three previous incidents in which signals were passed at stop (SPAS) or danger (SPAD) (see paragraph 66).

External circumstances

- 21 The weather at 17:20 hrs on 17 May 2019 at Manchester Airport, which is about 13 km (8 miles) south of Deansgate-Castlefield tram stop, was recorded as fair with no rain and an ambient temperature of 17°C. Witness evidence was that the weather at the tram stop at the time of the incident was fine and sunny.
- 22 Records show the sun was to the rear of the tram and shining towards the north-east. Although this means that the sun may have been shining onto the head of signal DCF06S, witness evidence and forward-facing CCTV (FFCCTV) showed that the driver's visibility of the signal was not affected by sunlight. There is therefore no evidence that external circumstances played a part in the incident.

⁵ Service braking is used for routine control of tram speed and uses dynamic motor braking. Under some circumstances, spring-applied friction disc brakes will also apply.

⁶ Hazard braking deploys the track brake which adheres magnetically to the rail head. The dynamic and friction brakes also apply, and sand is deposited onto the rail head to improve rail adhesion.

The sequence of events

Events preceding the incident

- 23 On the morning of 17 May 2019, the driver got up at 07:30 hrs, having finished work the previous evening at 20:11 hrs. He left home between 11:00 and 11:30 hrs and arrived at Queen's Road tram depot at about 12:00 hrs, where he booked on and started work. He then travelled from the depot as a passenger to Victoria tram stop, where he took over tram 83 at 13:09 hrs. His first scheduled duty was the outbound leg of a return journey to Manchester Airport.
- 24 On arrival at the airport, the driver had a wait of seven minutes before he started the return leg to Victoria. Once the tram arrived back at Victoria, there was a further wait of six minutes. The driver spent these periods in the tram's cab, in line with his normal practice. The tram departed Victoria for the airport for a second time at 15:21 hrs. OTDR and witness evidence suggest that the first return journey and second outbound leg to the airport were uneventful.
- 25 On arriving at the airport for the second time, the driver had another six-minute wait, which he again spent in his cab. The tram left the airport for the second return journey to Victoria at 16:25 hrs. At about 16:53 hrs, as the tram reached Wythenshaw Park (figure 3), the driver stated that he experienced pins and needles and cramp in two fingers of his left hand, which was operating the TBC. The driver flexed his fingers and got a minor sensation of pins and needles in his tongue and jaw. These sensations passed and did not concern the driver, who continued the journey. OTDR records did not indicate any obvious changes in the handling of the tram around this time.
- 26 At 17:16 hrs the tram left Cornbrook about 4 minutes behind schedule. Evidence from CCTV and the OTDR showed that the driver's dispatch of the tram from Cornbrook was in line with normal operating practices.
- 27 On leaving Cornbrook, the tram entered a section of track with a speed limit of 30 mph (48 km/h). On the day of the incident, this section of track included several temporary speed restrictions. The tram's OTDR recorded two occurrences in this section when the tram's speed exceeded the speed limit by around 6 mph (10 km/h). The tram was recorded as travelling under the speed limit as it passed through the 25 and 15 mph (40 and 24 km/h) limits in place on the immediate approach to Deansgate-Castlefield (paragraph 8).
- 28 Because the inbound platform was already occupied, tram 83 was directed by TMS into the centre platform. The tram was braking and travelling at slightly over the permitted 10 mph (16 km/h) speed limit as it approached the platform. TMS data shows that the driver of inbound tram 38, which was at a stand on the inbound platform, sent a TRTS request for DCF07S signal around the time tram 83 approached the centre platform.

Events during the incident

- 29 At 17:19:02⁷ hrs, tram 83 was travelling at 8 mph (13 km/h) as it approached the pedestrian crossing at the west end of the centre platform. At this point the driver moved the TBC from BRAKE into COAST. Four seconds later, with tram 83 travelling at 8 mph (13 km/h) and passing down the centre platform (figure 7), the driver moved the TBC from COAST into DRIVE, with a traction demand of +1%. Signal DCF06S is visible in FFCCTV images shortly after this point. It can be seen showing a stop aspect, which applied to tram 83.



Figure 7: FFCCTV image from tram 83 as the TBC moved from COAST and into DRIVE at +1% (image courtesy of Keolis Amey Metrolink)

- 30 At 17:19:13 hrs, DCF07S signal changed to proceed and tram 38 started to move away from the inbound platform a few seconds later. Tram 83 was by now further along the centre platform (figure 8). FFCCTV shows that signal DCF06S was still showing a stop aspect and that PPI DCF06P was showing a left indication.
- 31 At 17:19:17 hrs, tram 83 was travelling at 10 mph (16 km/h) and approaching the end of the centre platform. The driver moved the TBC from DRIVE to BRAKE, with a brake demand of -1%. Signal DCF06S remained at stop. Two seconds later, tram 83 passed clear of the platform and approached the pedestrian crossing at the east end of the tram stop (figure 9). This was being used by members of the public. The driver sounded the tram's whistle twice and increased the brake demand to -38%.

⁷ All times quoted are adjusted to synchronise with the timestamp of the OTDR on tram 83.



Figure 8: FFCCTV image showing the position of tram 83 as tram 38 (extreme left) moved off from the inbound platform (image courtesy of Keolis Amey Metrolink)

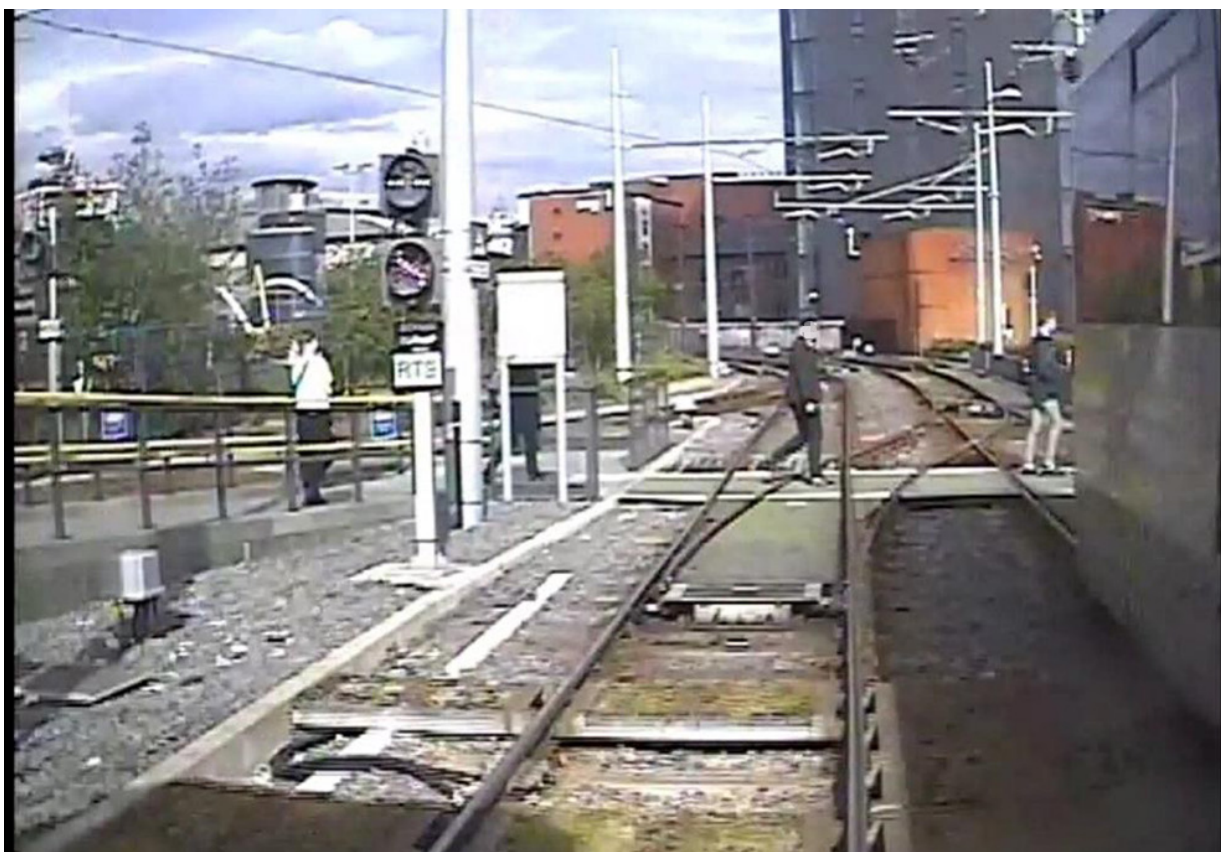


Figure 9: FFCCTV image showing signal DCF06S at STOP as tram 83 approached (image courtesy of Keolis Amey Metrolink)

- 32 Tram 83 passed signal DCF06S while it was showing a stop aspect at a speed of 9 mph (14 km/h). As the tram got closer to the pedestrian crossing, a member of the public realised that it had not stopped at the platform⁸ and stepped back to allow it to pass (figure 10). Once the front of the tram was over the crossing, the driver moved the TBC from BRAKE into DRIVE, with a traction demand of +1%. The driver of tram 83 made no further control inputs as the tram passed onto junction DCF07J.



Figure 10: FFCCTV image showing the pedestrian crossing as tram 83 approached (image courtesy of Keolis Amey Metrolink)

- 33 Junction DCF07J is not subject to a 'Give Way' arrangement. Under the line-of-sight principle (paragraph 9), the driver of tram 38 was therefore only required to check that signal DCF07S was showing a proceed aspect and that the line ahead was clear of obstructions, before he departed from the inbound platform. FFCCTV confirms that these conditions were met as tram 38 departed (figure 11). In this instance, the driver of tram 38 happened to glance to the right as he was approaching the junction. He saw that tram 83 was also approaching the junction and was able to bring tram 38 to a stand and narrowly avoid a collision (figure 2). The driver of tram 38 subsequently reported the near miss to Metrolink's Network Management Centre.

⁸ Trams are required to call at all stops on the Metrolink system.



Figure 11: FFCCTV image from tram 38 showing signal DCF07S and the line ahead (image courtesy of Keolis Amey Metrolink)

Events following the accident

- 34 Following the near miss, tram 83 continued on the inbound line at slow speed and entered the descending ramp which takes the tramway into on-street running.⁹ The OTDR recorded very small TBC movements between COAST and DRIVE during this period. At 17:20:00 hrs a passenger activated a passenger emergency call unit in the tram's saloon to ask the driver why the tram had not called at Deansgate-Castlefield. The driver had a brief conversation with this passenger. Larger TBC movements were recorded on the OTDR a few seconds after this call.
- 35 The tram called correctly at St Peter's Square and the driver completed the remainder of the journey to Victoria without further incident. On arrival at 17:33 hrs, the driver was relieved for a scheduled meal break and another driver took over the tram.

⁹ A mode of tramway operation where the part of the highway occupied by the tracks may also be used by other vehicles or pedestrians.

Analysis

Identification of the immediate cause

- 36 **Tram 83 entered junction DCF07J because the driver did not stop the tram in the platform or obey the stop aspect being shown by signal DCF06S.**
- 37 Evidence from witnesses, CCTV, OTDR, and TMS data shows that the driver of tram 83 made no attempt to stop the tram at the platform or to respond to the stop signal.

Identification of causal factors

- 38 The driver of tram 83 knew he was approaching the centre platform at Deansgate-Castlefield before the incident occurred. He stated that he remembered passing the 10 mph (16 km/h) speed limit and the pedestrian crossing at the west end of the platform (paragraph 31). The platforms then disappeared from his view and he experienced a visual phenomenon which he described as being like a red bubble which was shimmering and moving. Within this visual phenomenon, the driver stated he could see a proceed aspect, so he carried on driving, although it was not clear to him which signal was showing proceed. The driver did not recall seeing people on the pedestrian crossing at the east end of the tram stop or sounding the tram's whistle when approaching it. His first clear memory after the incident was the passenger emergency call alarm sounding as the tram descended the ramp towards St Peters Square.
- 39 The driver of tram 83 was familiar with the layout of Deansgate-Castlefield and had passed through the centre platform earlier the same day. Records provided by KAM showed he had the correct route knowledge¹⁰ to operate trams through the stop.
- 40 TMS data shows no evidence of an incorrect or unfamiliar signal aspect sequence which could have confused the driver. Given the relative positions and visibility of the signals at the east end of the tram stop, it is unlikely that the driver of tram 83 would have read across to the proceed aspect being shown by signal DCF07S. Even if the driver had read across between signals, he should have still stopped at the platform because of the requirement to call at all tram stops and because he would have been aware that DCF06S should show a stop aspect until he requested the route and it was granted (paragraphs 12 and 38).
- 41 For similar reasons, he is unlikely to have passed the platform and signal DCF06S due to any confusion between the left indication on PPI DCF06P and a proceed signal. It is of note that PPIs on the Metrolink system use orange LEDs as opposed to the white LEDs found in tram signals, further reducing the likelihood of this error being made.

¹⁰ The knowledge and appropriate practical operating experience necessary to enable drivers to work trams safely over a route.

- 42 The driver wore glasses for reading and distance vision, including when driving trams. The driver stated that he had no difficulties with reading signal aspects on the day of the incident. The driver underwent an eye test before he started training in June 2017, as part of a medical examination to establish his fitness to drive trams (see paragraph 56). This test found that the driver did not need to wear glasses to meet the standards required for tram drivers on Metrolink.
- 43 There was no evidence of any concerns having been raised by a supervisor about the driver's fitness for duty when he booked on at Queen's Road depot (paragraph 23). Post-incident testing showed that the driver was not impaired by drugs and alcohol during the incident and his medical records showed that he had not been prescribed any medication which could have impaired his fitness for duty.
- 44 Taking account of the preceding paragraphs, RAIB considers that the SPAS and near miss occurred because;
- the driver of tram 83 was affected by a temporary loss of awareness as the tram approached the platform and signal DCF06S (paragraph 45)
 - the driver's safety device on the tram was not designed to detect a loss of awareness by drivers and so did not mitigate the temporary loss of awareness experienced by the driver of tram 83 (paragraph 90).

Each of these factors is now considered in turn.

Tram driver loss of awareness

45 The driver of tram 83 was affected by a temporary loss of awareness as the tram approached the platform and signal DCF06S.

- 46 The driver of tram 83 stated that he had no clear recollection of failing to call at Deansgate-Castlefield tram stop or of passing signal DCF06S at stop (paragraph 38). OTDR and CCTV evidence show that he also did not operate the tram's controls in reaction to these events (paragraphs 29 to 33). This indicates that the driver was affected by a temporary loss of awareness as tram 83 passed through Deansgate-Castlefield.
- 47 While OTDR and CCTV evidence show the driver apparently reacting to the presence of people on the pedestrian crossing at the east end of the tram stop (paragraph 31), this is not inconsistent with him experiencing a loss of awareness because a person may still react automatically to salient external stimuli without necessarily fully processing their surroundings at a conscious level.
- 48 Although some doubt remains as to the exact reason for the driver's temporary loss of awareness, RAIB has concluded that it occurred because either;
- a. the driver was affected by a medical event (paragraph 49); or
 - b. the driver lost attentional focus on the driving task (paragraph 59).

Medical event

The driver's medical history

- 49 Witness evidence and an examination of the driver's personal medical records did not reveal any pre-existing medical condition or medical treatment that could have caused a temporary loss of awareness.

- 50 The driver suffered from migraines as a child but had not experienced one since the age of 16. While the episode of pins and needles that the driver stated he experienced at Wythenshaw Park (paragraph 25) reminded him of a post-migraine symptom, he had not previously experienced anything like the symptoms which occurred at Deansgate-Castlefield (paragraph 38). The symptoms which he experienced have also not reoccurred between the incident and the publication of this report.
- 51 The driver stated that at some point in the two years before the incident, he had suffered a migraine-like loss of vision while driving his car. He stopped his car but did not develop a migraine and his vision cleared within a few minutes. The driver did not consider that this episode affected his ability to drive or required him to seek medical advice.
- 52 Post-incident medical tests and examinations of the driver found that he did not show any disposition to seizure and that the episode did not seem to have been caused by a transient ischemic attack (TIA) or stroke. Medical specialists concluded that, while it was difficult to be sure, the episode may have been the result of a partial complex seizure or an acaphelegic migraine (a migraine without aura).

KAM's medical procedures

- 53 KAM's medical procedure requires all candidates to undergo a pre-employment medical. This includes a questionnaire about the candidate's past medical history and a physical examination by a doctor. The procedure states that employees undertaking safety critical roles, such as driving trams, are not permitted to have a condition that causes:
- sudden loss of consciousness
 - impairment of awareness or concentration or sudden incapacity
 - impairment of balance or co-ordination
 - significant limitation of mobility
 - visual impairment of a temporary or transient nature.
- A history of epilepsy and other specific neurological conditions may also exclude staff from undertaking safety critical roles.
- 54 Once recruited, staff are required to undergo periodic medical examinations to ensure that they continue to meet the appropriate requirements. The Metrolink rule book in force at the time of the incident required staff not to come to work if they were ill '*...to the extent that it affected their own or someone else's safety*' and for any driver subject to medical restrictions (either by the company itself or by their personal doctor) that may affect their qualification to drive to report this to their supervisor immediately.

- 55 In practice, KAM and the previous franchisee Metrolink RATP Dev Ltd (MRDL) required drivers to pass a medical examination to the standard¹¹ required by Network Rail for personal track safety (PTS) certification. This has similar requirements to KAM's medical procedure with respect to not permitting medical conditions or medical treatments likely to cause sudden loss of consciousness, impairment of awareness or concentration. Managers working for KAM stated that the PTS medical standard had probably been introduced for drivers because trams run over Network Rail managed infrastructure when operating on the line to Altrincham.
- 56 The driver of tram 83 passed medical examinations to the PTS standard during his initial recruitment by MRDL in November 2016 and again in June 2017, just before he started training as a tram driver with KAM (who had taken over operations). Neither of these examinations recorded any medical condition or treatment which could have produced a temporary loss of awareness in the driver. There was also no record of the driver having made any report of a change in his medical condition during his employment with KAM. The driver did not consider the episode which he experienced when driving his car (paragraph 51) as having any adverse impact on his ability to drive safely.
- 57 At the time of the incident, the driver held both a Category B car licence (required to drive trams) and a Category D bus driving licence (due to his previous employment as a bus driver). The driver passed a medical to the Group 2 standard required by the Driver and Vehicle Licensing Authority (DVLA) for a Category D bus driving licence holder in 2016.
- 58 Neither the driver's medical history, nor examinations by medical specialists, show any clear evidence that the driver had a relevant medical condition that could have been detected by medical examination before or during his employment as a tram driver. For this reason, the medical requirements for tram drivers put in place by KAM and MRDL are not causal to this incident. The suitability of KAM's medical requirements for tram drivers is discussed further in paragraph 106.

Loss of attentional focus

- 59 The risk of a driver suffering from a loss of attentional focus (sometimes referred to as a lapse in concentration) can be affected by a variety of environmental and individual factors. RAIB has found no evidence that:
- The environment within the tram's cab or its design and layout adversely affected the driver.
 - The driver was experiencing underload (reduced mental demand). The approach to Deansgate-Castlefield is visually distinctive and requires frequent control inputs to meet the varying speed limits (paragraph 8). The loss of awareness also took place at a point where the driver's workload would be relatively high because he was approaching the pedestrian crossing and a platform.
 - The driver was subject to overload (excessive mental demand). Witness evidence suggests this was a normal day for the driver and that, while the tram was slightly late, the driver did not feel subject to time pressure. There were also

¹¹ The medical standards for a variety of track safety competences are given in Network Rail standard NR/L2/OHS/00124 'Competence specific medical fitness requirements and occupational health provider requirements for medical assessments', Issue 3, March 2017.

no unusual or degraded operations being undertaken.

- There was anything in or outside of the tram that distracted the driver, including calls or activity being made from mobile telephones.

- 60 There is nothing that suggests the driver was subject to the effects of fatigue when the incident occurred. The driver was on his second day back at work after a ten-day period of rest. He stated that he slept for between 8 and 8.5 hours on the night before the incident and that there had been no recent disruption to his sleep.
- 61 Although he was approaching his scheduled break at the time of the incident (paragraph 34) the driver stated that he did not feel tired and that he felt '*fine*'. He also stated that had eaten breakfast and lunch before work and drank a coffee before taking over the tram at Victoria. This is likely to have reduced the risk of him feeling fatigued. The short gaps during turnarounds which would have allowed him to focus away from driving (paragraphs 24 and 25) may also have helped to reduce the effects of fatigue on the driver. KAM's management of fatigue risk is discussed further in paragraph 112.
- 62 While it is not possible to entirely discount the driver's temporary loss of awareness having been caused by a microsleep, RAIB has found no evidence to suggest that this was the case.
- 63 A microsleep is an unintentional period of sleep lasting anywhere from a fraction of a second to a few minutes, although it typically lasts from around 5 to 15 seconds. It is often characterised by a closing of the eyes or head nodding, a loss of connection to the external environment and a failure to respond to outside information. The risk of a microsleep increases if a person has a cumulative sleep debt or if they are otherwise subject to the effects of fatigue. It can be affected by factors such as low or undemanding workload, the time of day, pre-existing medical conditions and shift-working.
- 64 The driver's loss of awareness lasted almost a minute after the tram approached the west end of the centre platform (paragraph 29). During this period, he appears to have responded to the presence of members of the public on the pedestrian crossing at the east end of the platform (paragraph 31). In addition, few of the factors seen as elevating the risk of a microsleep were present during this incident. While the driver was a shift-worker, there was no evidence that he was fatigued. Furthermore, the loss of awareness took place during a period of relatively high workload and just after the typical afternoon circadian low point. The driver also had no health conditions that could have raised the risk of a microsleep (paragraph 49).
- 65 There is conflicting evidence as to whether the driver may have been distracted by issues in his personal life at the time of the incident. RAIB has concluded that this is something that could have affected his focus on the driving task.

Driver's previous safety incidents

- 66 The driver of tram 83 had been involved in three previous SPAD or SPAS

incidents before 17 May 2019.

- 67 The first incident occurred on 9 February 2018, when the driver departed from a platform at Piccadilly station and subsequently passed a stop signal. This activated the SPAS lights (see paragraph 100) at this location, which caused him to bring the tram to a stand. The driver stated that he had pressed the RTS button to request the signal before departing and that he thought he had seen the signal 'pulse' in response. KAM's internal report stated that CCTV showed that the signal remained at stop. KAM's report found that the cause of the SPAS was a *'clear lack of concentration on the drivers part [sic]'*.
- 68 The second incident occurred on 9 April 2018, when the driver approached a danger signal on the block-signalled Altrincham line in foggy conditions and did not stop the tram in time to prevent a SPAD. The signal was at danger due to a failure of signalling equipment, which had also affected other signals and prevented controllers in the Network Management Centre from detecting the SPAD. The driver did not report the SPAD and was subsequently authorised by a controller to pass this signal and a second signal beyond it, which was also at danger due to the fault. The driver passed the second signal as authorised but then went on to pass a third signal at danger without authority. This third signal was functioning correctly and was protecting the single line ahead, which was occupied by another tram. The driver allowed his tram to enter the single line section and to pass over a level crossing before the barriers to road traffic were lowered. On seeing the other tram, which was stationary at a tram stop, the driver brought his own tram to a stand.
- 69 KAM's internal investigation found multiple causes of this incident. These included the tram driver's route knowledge, his control of the tram and his failure to report the initial SPAD. The internal investigation also found that the driver may have been suffering with sleep issues due to personal problems and that he should not have been driving on this route, which was new to him, because he was still under an action plan resulting from the first incident. The internal investigation found that there were no effective checks on route knowledge after drivers learnt new routes. It also found issues with the controller's communications with the driver and with wider safety critical communications training and assessment.
- 70 The third incident took place on 5 April 2019, when the driver was distracted by the presence of railway staff as he approached a platform at Victoria station. This caused him to leave insufficient distance to brake before a stop signal, which the tram passed by a short distance. An internal investigation by KAM found that the driver *'lost situational awareness which caused him to lose focus on his position in relation to the signal'*.

KAM's recruitment and training of the driver

- 71 KAM's driver selection and training procedure requires candidates to be 'well-motivated and safety conscious', pass psychometric testing which demonstrates their suitability for a driving role and to undergo a selection interview. KAM carries out further assessments in addition to those listed in the procedure. These include an assessment of a candidate's ability to work to instructions, by observing how they drive on a simulator, requiring candidates to

discuss how they had handled a safety matter and an assessment of a safety-based role-play exercise.

- 72 The driver underwent this enhanced selection process in November 2016 and met the standards required. This included passing the Safe Concentration and Attention Test (SCAAT), a test of a person's capacity to maintain concentration. SCAAT is similar to a type of test deemed suitable by rail industry standards for use in train driver selection.
- 73 Between July and September 2017, the driver went through what was then KAM's standard 12-week driver training programme. The training records for the driver show that he completed his training without incident but failed the final written exam. He passed this exam on the second attempt and then started driving with a minder driver. The initial feedback from the minder was that the driver needed to work on his concentration and speed control and that he should use commentary driving as a tool to do this. While further occasional issues with concentration were noted, training records stated that he appeared to have taken this guidance onboard and had progressed '*very well*'. The driver passed his final practical driving test on 19 October 2017.
- 74 Newly qualified drivers undergo assessments known as ride checks one, three and six months after passing their test. They also start driving in service on the lines which they developed route knowledge of during training. Drivers involved in safety-related operating incidents are not permitted to learn additional routes for a minimum period of three months following the conclusion of the related investigation. At the time the driver was employed this also acted as a financial penalty, as the learning of additional routes triggered a rise in driver grade and an associated increase in pay. Managers at KAM stated that this link between additional route learning and pay is no longer in place.
- 75 There were no records of the one or three-month ride checks undertaken on this driver and the first SPAS occurred before the six-month ride check or 12-month assessment could take place. It is therefore not possible to say if there were further issues with the driver's ability to maintain focus and avoid distraction immediately after his initial training.

KAM's management of safety-related incidents

- 76 Safety-related incidents involving drivers are investigated by KAM in accordance with several procedures.¹² The process sees the driver involved being relieved from duty and tested for the presence of drugs and alcohol. They are then suspended from driving duties while an initial investigation is undertaken. If no technical cause is found, such as an equipment malfunction, then the driver may be dealt with by KAM's disciplinary process or referred to an Employee Assessment and Assistance Panel (EAAP).

¹² Guidance on the assessment of staff following incidents and the management of performance is provided in the Office of Rail and Road's Railway Safety Publication 1 'Developing and maintaining staff competence', November 2016, https://orr.gov.uk/_data/assets/pdf_file/0016/4264/developing-and-maintaining-staff-competence-rsp1.pdf

- 77 For drivers, the EAAP consists of the Head of Drivers or Driver Manager, KAM human resources, a representative of the relevant trade union and a second tram driver. The role of the panel is to review the incident and the past performance of the staff involved and to make recommendations as to how they should be supported in the future. This could include recommending that they return to duty or that their safety critical duties be adjusted. As part of a recommendation that a staff member return to duty, an EAAP can require them to follow an action plan. An EAAP can also refer an individual back to their line manager to be dealt with under KAM's disciplinary process.
- 78 KAM's procedures state that an action plan should '*relate to individuals [sic] shortfalls and needs with the objective of improving the individual's safety performance*'. Action plans are categorised as low, medium and high, corresponding to the levels of support required. Staff subject to an action plan move up one level at a time, with each move requiring 12 months to have passed and a line manager's agreement. Moving from a low category action plan and back to normal duties requires six months to have passed and further line manager consent. Line managers are required to review the plans every three months and the way they are implemented should be subject to a wider six-month review by KAM's service delivery department.
- 79 KAM's procedures place an emphasis on action plans using assessments to measure improvement, although re-training, changes in duties, medical exams, psychometric tests, welfare meetings and lifestyle education are also discussed as options. KAM's procedures also state that an assessment of capability for a driver would normally take place if they had been involved in four operating incidents in any two-year period. The procedure states that this threshold can be reduced where there are identified trends or '*a recurrence of human factor concerns within the preceding five-year period*'. A capability assessment is used to determine if safety critical staff remain suitable to carry out an activity. Such assessments are regarded as being distinct from the disciplinary process, which considers a person's conduct.
- 80 The joint KAM – TfGM business plan covering the period 2019-2021 has an objective that both organisations adopt a '*Just Culture that is fair and transparent to all, with a clear focus on eradicating employee and contractor injuries...*'. In a safety context, a 'just culture' (sometimes referred to as a 'fair culture') is seen as a culture of trust, learning and accountability in which people are not punished for actions, omissions or decisions which are commensurate with their experience and training, but where gross negligence, wilful violations and destructive acts are not tolerated.
- 81 An EAAP placed the driver on a low category action plan following the first SPAS to address its finding of a '*clear lack of concentration*' (paragraph 67). This plan included the driver receiving advice on the need to avoid distraction and working half a shift with a minder, to include passing the signal involved in the SPAS. The action plan also included a mix of formal and unannounced assessments and the standard requirement that no new routes be learned by the driver for three months (paragraph 74). The Head of Drivers and the Driver Manager were responsible for ensuring that the plan was implemented.

- 82 The driver's records showed no evidence that this action plan was ever implemented. Records also showed that the driver was trained on new routes within a few weeks of the investigation concluding, contrary to the action plan and the relevant KAM procedure. A later investigation by KAM concluded that this had occurred because the action plan had not been communicated to the supervisors responsible for organising route learning.
- 83 There is no evidence that the performance of the driver during the second incident was reviewed by an EAAP. It appears that the investigation report (paragraph 68) was instead passed directly to the Driver Manager, who instigated KAM's disciplinary process. This resulted in the driver receiving a final written warning in August 2018. This warning included a 15-month action plan that mandated a period of retraining, a three-week period of minder driving and a requirement to re-sit the practical driving test. It also required the driver have monthly meetings with a mentor and a number of assessed OTDR downloads and driving assessments. The warning stated that any further incidents would be likely to result in the driver's dismissal.
- 84 There was evidence in the driver's records that the retraining and assessment elements of this second action plan were implemented and that they included both a successful re-taking of the practical driving test and the ride checks required of a newly qualified driver. However, there was nothing to show if or how the monthly mentoring or coaching elements of the plan were implemented once the driver returned to duty.
- 85 RAIB also notes that a disciplinary mechanism was used following the second incident to address both the driver's mistakes as well as those actions found by KAM to be rule violations. Managers at KAM stated that it was normal practice to instigate disciplinary action following a second operating incident by a driver, regardless of whether it related to mistakes or violations. The use of disciplinary processes to address unintentional actions is not considered good practice within a just culture because it can affect the willingness of staff to report near misses and suppress opportunities to learn safety lessons. This means it is likely to inhibit the longer-term development of a just culture. A reluctance by drivers to report mistakes because they believed this would result in measures such as disciplinary action was a finding of the RAIB report into the overturning of a tram at Sandilands junction, Croydon on 9 November 2016 (see paragraph 120).
- 86 Records showed that an EAAP reviewed the driver's actions following the third incident and that it recommended a low category action plan to address its finding of '*distraction causing loss of situational awareness*' (paragraph 70). Because the final written warning resulting from the second incident was still active, this plan was passed to the Head of Drivers. This resulted in further disciplinary action, with the driver being issued a second final written warning. This re-applied the assessment and mentoring requirements resulting from the second incident and extended the driver's final warning period for a further 15 months. This is another example of the disciplinary process being used to address actions found by KAM to be unintentional.

- 87 There is evidence that the driver received mentoring in the form of minder driving once he returned to driving duties because of this action plan. This continued until 16 May 2019, the day before the incident. There was, however, no evidence that the driver's suitability for continuing in a driving role was considered following the third incident. The driver had not reached the threshold of four incidents in any two-year period that would trigger a capability assessment under KAM's procedures (paragraph 79). However, the internal investigations into the first and third incidents both concluded that the driver had not effectively maintained focus and the relevant procedure permitted a capability assessment to be undertaken before the usual threshold in these circumstances.
- 88 Figures provided by KAM also showed that some drivers remained in service who had accumulated a higher number of incidents than the threshold value, and it was not clear from discussions with KAM senior managers when a capability assessment would be initiated in practice or how it would be undertaken. This was despite a study undertaken by the previous franchisee which showed that drivers were at an elevated risk of further SPAS/SPAD if they had previously been involved in multiple incidents.
- 89 While it is difficult to quantify exactly what difference better implementation of action plans or an assessment of the driver's capability would have made, KAM had several opportunities to more effectively address this driver's safety performance before the incident of 17 May 2019.

The driver's safety device

90 The driver's safety device on the tram did not detect and mitigate the temporary loss of awareness experienced by the driver of tram 83 because it was not designed to do so.

- 91 M5000 type trams are fitted with a Driver's Safety Device (DSD). This is intended to stop the tram if the driver becomes incapacitated. The DSD does this by requiring the driver to press down on the TBC (paragraph 18). If the TBC is released, then an audible warning will sound. Pressing the TBC back down will silence the alarm. This can only be done while the TBC is in the central or braking positions. If the alarm is not silenced after four seconds, then hazard braking (paragraph 18) will automatically be applied. The application of hazard braking and the status of the DSD are recorded by the OTDR.
- 92 Since tram 83 continued in service following the incident (paragraph 34), the function of the tram's DSD was not tested afterwards. However, no issues were reported with the TBC or the DSD by the driver involved in this incident or by the driver who took over the tram from him later. OTDR data showed that changes in DSD status were recorded when the driver changed ends between trips, suggesting that the OTDR was correctly recording the status of the DSD.
- 93 There was no indication from OTDR records that the DSD was activated or that hazard braking was applied as tram 83 passed through Deansgate-Castlefield. In addition, the small TBC movements recorded during the incident (paragraphs 29 to 34) showed that the driver's hand remained on the controller. Taken together, this shows that the driver was able to operate and maintain downwards pressure on the TBC despite his loss of awareness. It also shows that the DSD did not detect or mitigate this loss of awareness.

- 94 The RAIB report into the overturning of a tram at Sandilands junction, Croydon on 9 November 2016 (see paragraph 120) found that a similar design of DSD would not activate in circumstances where a driver ceased to be vigilant but was still able to maintain sufficient downward pressure on the TBC. The investigation found that the weight of a person's arm alone may be sufficient to maintain the pressure required. The report also includes details of previous railway accidents where a driver lost attention or became incapacitated and this was not detected by the DSD.

Identification of underlying factors

KAM, Thales and TfGM's recognition and control of risk

- 95 **KAM, Thales and TfGM either did not recognise the hazard of a driver losing awareness while operating a tram on the Metrolink system or did not fully control the associated risk.**
- 96 As part of the Deansgate-Castlefield remodelling programme (paragraph 6), the Thales project team undertook a risk assessment of the proposed new signalling layout. This was known as the Local Hazard Assessment (LHA). The LHA was based on the findings of two preliminary hazard identification workshops held in October 2014. These workshops involved staff from Thales, TfGM and MRDL and used a recognised process to identify hazards.
- 97 The LHA considered a tram's specific position within the stop, any potential conflicting moves and the types of hazard present. Thales stated that the LHA was continually revised as the project progressed and that it was reviewed by an internal inter-disciplinary panel as the project reached design, installation and testing milestones. Once an internal review had been completed, the LHA was passed to TfGM for its own review and approval. If approval was granted by TfGM, then the project moved to its next stage and the LHA continued to be developed. The final version of the LHA was that submitted to TfGM and KAM in November 2018 as part of their approval of the modified signalling at Deansgate-Castlefield for revenue earning service.
- 98 In December 2018 KAM revised its own local risk assessment of the layout and signalling system at Deansgate-Castlefield. This assessment focused on the operational impacts of the new layout and was also submitted as part of gaining approval for the entry of the modified layout into revenue earning service.
- 99 Both the LHA and KAM's local assessment specifically considered the hazard of a collision between trams using the inbound and centre platforms following a SPAS of signal DCF06S. The assessments noted that there was no SPAS protection fitted to DCF06S but that the visibility between the converging routes at junction DCF07J was adequate for the risk of collision to be obvious to drivers.

- 100 SPAS protection uses short axle counter blocks to detect the presence or absence of trams at selected signals within the tram stop. If a tram passes a signal at stop which is protected in this way, the overrun will be detected and TMS will return all signals within a specified zone to STOP. SPAS protection will also activate blue flashing SPAS lights to alert the driver who has overrun the signal and any other drivers on potentially conflicting routes. The Metrolink rule book in force at the time of the incident stated that SPAS protection was only required '*on single line sections and/or at converging junctions with limited visibility*'. The absence of SPAS protection at junction DCF07J was therefore consistent with these rules. Information provided by TfGM and KAM showed that the lack of SPAS protection at this junction did not differ from the practice at some other comparable locations on the Metrolink network.
- 101 The hazard of a driver becoming unaware or unresponsive while driving a tram through Deansgate-Castlefield was not identified in the local assessments undertaken by Thales and KAM or during the review of the LHA by TfGM. These risk assessments also did not consider how an unresponsive driver would affect the control measures identified for other hazards identified in the assessment which also relied on the line-of-sight principle and the correct action of the driver.
- 102 In June 2018, managers from KAM's driving, training and safety functions undertook a general risk assessment of the tasks undertaken by a tram driver. This identified the overall hazard of signals being passed at stop or danger as well as a specific hazard of a SPAS/SPAD or other incident as a result of a tram driver becoming distracted or losing concentration. The risk controls assigned to these hazards were the recruitment of drivers (including selection interviews and psychometric testing for concentration), the holding by drivers of a current driving licence, driver training and competency assessment, route knowledge, SPAS/SPAD awareness and post-incident investigation.
- 103 While this general risk assessment identified the hazard of SPAS/SPAD because of a driver losing concentration, it did not consider other potential causes of driver loss of awareness, such as a medical event or microsleep, where the risk controls listed are unlikely to be effective. The risk assessment also did not consider how the risk of a SPAS/SPAD could be addressed by the design of equipment or infrastructure (such as SPAS protection or controlling approach speeds) or by controlling influences on human performance.
- 104 RAIB's investigation into the overturning of a tram at Sandilands junction, Croydon on 9 November 2016 (see paragraph 120) found that the accident was caused by the driver of the tram not applying sufficient braking, likely due to them suffering a temporary loss of awareness of the driving task. The RAIB investigation report included a recommendation that tram operators in the UK better understand the safety risks associated with tramway operation. The final version of the LHA was issued and reviewed after that accident and the publication of the RAIB report. Both of KAM's risk assessments were similarly undertaken after the publication of the RAIB report. Given the extensive publicity that the report's findings received within the light rail industry, it is not clear why these assessments and reviews either did not identify the hazard and/or fully address the associated risk of an unresponsive or unaware tram driver.

105 Documents provided by TfGM showed that the hazard workshops for the signalling system did not take place until after the physical layout of the stop had been fixed. This was because the signalling system was subject to a separate contract that was awarded later than that for the main remodelling project. The fixing of the physical layout prior to the hazard workshops meant that some risk controls (such as SPAS protection) could not have been implemented by Thales at signal DCF06S, even had they been identified as potentially effective.

Observations

Tram driver medical standards

106 The medical standard used for tram drivers by KAM had not been assessed against the risk of unavoidable impairment when driving trams on a line-of-sight basis.

107 KAM and MRDL required tram drivers to pass a medical examination to the standard mandated by Network Rail for PTS certification. This states that individuals '*...should not be suffering from medical conditions, or be taking any medical treatment, likely to cause:*

- a. sudden loss of consciousness;*
- b. impairment of awareness or concentration;*
- c. sudden incapacity;*
- d. temporary visual impairment...*

108 'Likely to cause' is defined as '*an unavoidable impairment¹³ over and above the acceptable frequency for specific tasks*'. These acceptable frequencies are set out in the RSSB document 'Managing the risk associated with sudden incapacity in safety critical occupations'.¹⁴ For a track worker maintaining, repairing or laying track, components or structures, a typical task for a holder of PTS certification, the acceptable frequency is 0.15 events per person per year. The track worker acceptable frequency is based on a finding that '*the likely outcome of a hazardous event is harm to the worker themselves rather than others*'.

109 As a comparison, a train driver driving a train on a running line has an acceptable frequency of an unavoidable impairment of 0.43 events per person per year. The RSSB document explains that driving a train on the running line tolerates a higher frequency of unavoidable impairment because trains are protected by highly reliable engineering controls. This would typically include systems that reduce the risk of SPADs, such as the Train Protection and Warning System (TPWS) and the Automatic Warning System (AWS).

110 In contrast to the track worker, a tram driver operating on a line-of-sight basis who becomes impaired may harm others. Tram drivers are also not protected by engineering controls in the same way as train drivers. This means that neither the track worker nor the train driver is a suitable model to use when judging the permitted level of unacceptable impairment in a tram driver.

¹³ A sudden incapacity or impairment due to a medical cause.

¹⁴ RSSB, 'Managing the risk associated with sudden incapacity in safety critical occupations', 2009 <https://catalogues.rssb.co.uk/research-development-and-innovation/research-project-catalogue/T663>.

- 111 The DVLA defines a maximum acceptable likelihood of a sudden disabling event for a car driver to be 0.2 events per person per year. For a bus driver this is reduced to 0.02 events per person per year. The track worker acceptable frequency adopted by KAM and MRDL (via their use of the medical requirements for PTS certification) is therefore closer to that required of car drivers rather than that required of bus drivers, even though the latter role is comparable in terms of the risk to passengers. Other aspects of DVLA's medical requirements for Group 2 licence holders (such as colour vision requirements) may not, however, be appropriate practice for tram driving roles.

The management of fatigue risk by KAM

112 KAM's management of fatigue risk did not meet with relevant industry guidance and best practice.

- 113 KAM did not have a documented fatigue risk management system in place at the time of the incident. However, KAM had issued a 'Driver Rostering & Allocation Parameters' document in November 2018. This was an agreement with the trade unions which defined how driver rosters were developed and how staff were to be consulted on them, via their trade union. It also included numerical limits on the number of hours worked, the minimum rest hours between shifts and targets for average working hours per week and per month. The document also required that the master roster be analysed using the Health and Safety Executive (HSE) [Fatigue Risk Index Calculator](#), with the aim that scores be reduced 'as low as possible'.
- 114 KAM also issued a series of 'life-saving rules' to its staff in February 2019. One of these rules is '*Be Fit for Work – Always ensure your safety is not impacted by fatigue*'.
- 115 RAIB observes that these arrangements did not meet current industry guidance¹⁵ or good practice with respect to managing fatigue risk in the following areas:
- there was no overall fatigue risk management policy in place which recognised the need to control fatigue
 - there was no comparison of work patterns against the ORR's 'Good practice guidelines - Fatigue Factors'¹⁶ to identify potentially fatiguing features
 - there was no provision made for training those involved in designing or negotiating working patterns in relevant good practice
 - although a confidential reporting system was available for employees to express safety concerns, there was no specific mechanism for staff to report concerns about their fitness for duty due to fatigue or anything which explained how such concerns should be dealt with by supervisors
 - there was no mechanism for measuring and monitoring fatigue in drivers
 - there were no designated key performance indicators relating to fatigue¹⁷

¹⁵ Office of Rail and Road 'Managing Rail Staff Fatigue', January 2012 https://orr.gov.uk/_data/assets/pdf_file/0005/2867/managing_rail_fatigue.pdf?web=1.

¹⁶ Office of Rail and Road 'Good practice guidelines - Fatigue Factors', December 2017 https://orr.gov.uk/_data/assets/pdf_file/0003/23682/good-practice-guidelines-fatigue-factors.pdf.

¹⁷ Office of Rail and Road 'Fatigue – Key Performance Indicators', May 2017 https://orr.gov.uk/_data/assets/pdf_file/0008/24758/fatigue-key-performance-indicators.pdf.

- there was no mechanism to assess the fatigue implications of overtime, rest-day working or shift swapping
- threshold fatigue risk index limits were still provided
- there was no recognition of the potential fatigue risks presented by commuting or out-of-work activities, or arrangements for educating staff on fatigue risks.

The effectiveness of KAM's strategy to reduce SPAS and SPAD

116 KAM's strategy to reduce the risk posed by SPAS/SPAD did not consider some of the factors that cause such incidents or increase the severity of their consequences.

117 KAM's safety management system includes a SPAS/SPAD reduction strategy. This acknowledges that such incidents may be a precursor to a major accident on the Metrolink network. The principal risk control measures identified in the strategy are the procedures covering the recruitment, training, competence assessment and performance monitoring of drivers. The strategy also refers to risk controls used in block signalling areas. The SPAS/SPAD reduction strategy is supplemented by the joint KAM-TfGM business plan, which provides annual SPAS/SPAD reduction targets.

118 RAIB observed that the SPAS/SPAD reduction strategy is out-of-date regarding its description of some of the risk controls in use within block signalling areas, and that it does not discuss some of the risk controls currently in use when operating under line-of-sight, such as SPAS protection. The strategy also does not consider some of the factors which the rail industry has made part of its approach to reduce SPADs¹⁸ and which have had a direct and recent impact on Metrolink operations. These include:

- a consideration of how SPAS/SPAD risk could be affected by changes to the network's infrastructure and operations such as the opening of new lines, the increase in the proportion of trams operating in line-of-sight mode, and timetabling changes
- how SPAS/SPAD risk may be influenced by external factors such as changes in the operating environment, due to the actions of outside parties
- the use of technology to reduce SPAS/SPAD
- how SPAS/SPAD investigation can be used to improve KAM's understanding of risk and to feed back into a review of the strategy itself.

¹⁸ RSSB 'Signals passed at danger - A summary of rail industry's approach to risk reduction', 2020 <https://www.sparkrail.org/Lists/Records/DispForm.aspx?ID=26755>.

Other occurrences of a similar character

Tram collision with pedestrian near Market Street tram stop, 12 May 2015

119 At about 11:13 hrs on Tuesday 12 May 2015, a tram collided with a pedestrian shortly after leaving Market Street tram stop in central Manchester. The pedestrian received serious injuries as a result of the collision. RAIB ([RAIB Report 06/2016](#)) found that the accident occurred because the driver did not apply the tram's brakes until around the moment of collision, despite the pedestrian being in the path of the tram for four seconds beforehand. MRDL's driver management processes were not considered a factor in the accident because there was no evidence that the driver involved had a persistent problem of inattentiveness. RAIB's report included a learning point that regular reviews and/or appraisals with tram drivers, undertaken by a line manager or other competent person, are important for identification and follow-up of any issues that might affect their driving performance.

Overturning of a tram at Sandilands junction, 9 November 2016

- 120 On Wednesday 9 November 2016, a tram running between New Addington and Wimbledon overturned on a curve as it approached Sandilands junction, in Croydon. Seven people lost their lives, 19 people suffered serious injuries and 43 people received minor injuries in the accident. The RAIB report into the accident ([RAIB Report 18/2017](#)) found that the tram was travelling too fast to negotiate the curve because the driver did not apply sufficient braking as a result of him losing awareness of the driving task during a period of low workload.
- 121 London Trams and Tram Operations Ltd not recognising the actual level of risk associated with overspeeding on a curve was found by RAIB to be an underlying factor. This was in part because route hazard assessments and risk profiling relied on driver performance as the main means of mitigating the risk. Additionally, while senior managers recognised the importance of learning from experience, a reluctance of some drivers to report their own mistakes was a factor which may have prevented Tram Operations Ltd from gaining a full understanding of previous similar occurrences.
- 122 RAIB made several recommendations in its report into this accident which are of relevance to the incident on 17 May 2019. The most relevant of these recommendations are discussed in paragraph 129.

Incident at Abraham Moss tram stop, Manchester, 14 October 2019

123 On 14 October 2019 a double unit¹⁹ Metrolink tram passed through the 10 mph (16 km/h) speed limit at Abraham Moss tram stop at a speed of up to 32 mph (52 km/h). The tram was brought to a stand by the driver with the centre and rear doors of the trailing vehicle accommodated in the platform and with the front of the tram sitting over a pedestrian crossing. During the over-run the tram also passed a sign at the end of the platform which required drivers to stop and check that the crossing was clear before proceeding.

¹⁹ A service which uses two vehicles coupled together.

124 KAM's internal investigation into this incident found that the driver of the tram had been distracted by issues in his personal life. As a result of the incident, the driver was subject to KAM's disciplinary process and was also offered minder driving support, which the driver declined. There is no evidence that an EAAP was convened following this incident.

Summary of conclusions

Immediate cause

125 Tram 83 entered junction DCF07J because the driver did not stop the tram in the platform or obey the stop aspect being shown by signal DCF06S (paragraph 36).

Causal factors

126 The causal factors were:

- a. the driver of tram 83 was affected by a temporary loss of awareness as the tram approached the platform and signal DCF06S (paragraph 45). RAIB has concluded that it occurred because either:
 - i. the driver was affected by a medical event (paragraph 49); or
 - ii. the driver lost attentional focus on the driving task (paragraph 59, **Recommendation 1**).
- b. the driver's safety device on the tram did not detect and mitigate the temporary loss of awareness experienced by the driver of tram 83 because it was not designed to do so (paragraphs 90 and 136, Recommendation 4 of [RAIB Report 18/2017](#)).

Underlying factor

127 An underlying factor was:

- a. KAM, Thales and TfGM either did not recognise the hazard of a driver losing awareness while operating a tram on the Metrolink system or did not fully control the associated risks (paragraphs 95 and 132, Recommendation 2 of [RAIB Report 18/2017](#)).

Additional observations

128 Although not linked to the incident on 17 May 2019, RAIB observes that:

- a. The medical standard used for tram drivers by KAM had not been assessed against the risk of unavoidable impairment when driving trams on a line-of-sight basis (paragraph 106, **Recommendation 2**).
- b. KAM's management of fatigue risk did not meet relevant industry guidance and best practice (paragraph 112, **Recommendation 3**).
- c. KAM's strategy to reduce the risk posed by SPAS/SPAD did not consider some of the factors that cause such incidents or increase the severity of their consequences (paragraph 116, **Recommendation 1**).

Previous RAIB recommendations relevant to this investigation

129 The following recommendations which have relevance to this investigation were made by RAIB following previous investigations.

[Overturning of a tram at Sandilands junction, 9 November 2016, RAIB report 18/2017](#)

[Recommendation 2](#)

130 This recommendation reads as follows:

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. The review should include:

- i. examination of the differing risk profiles of on-street, segregated and off-street running;*
- ii. safety issues associated with driving at relatively high speeds in accordance with the line-of-sight principle in segregated and off-street areas, particularly during darkness and when visibility is poor;*
- iii. current practice world-wide and the potential of recent technological advances to help manage residual risk;*
- iv. safety learning from bus and train sectors that may be applicable to the design and operation of tramways;*
- v. consideration of the factors that affect driver attention and alertness across all tram driving scenarios in comparison to driving buses and trains; and*
- vi. guidance on timescales for implementing new control measures (eg whether retrospective or only for new equipment).*

Using the output of this review UK tram operators, owners and infrastructure managers should then, in consultation with ORR, publish updated guidance on ways of mitigating the risk associated with design, maintenance and operation of UK tramways.

131 TfGM stated that, in response to this recommendation, it had worked with KAM to support UK Tram with the development of a new light rail safety risk model. This had included the development of risk profiles for individual networks. The profile for Metrolink was published in August 2019. TfGM said that it continues to work with KAM to support the light rail safety risk model by providing operational safety data to the Light Rail Safety and Standards Board²⁰ (LRSSB).

²⁰ LRSSB was established in response to a recommendation in RAIB's report into the overturning of a tram at Sandilands junction. It builds on the work of the UK Tram safety steering group and is intended to act as a safety and standards body for the light rail sector. LRSSB is a subsidiary company of UK Tram and has a ringfenced budget and a separate governing body from the main UK Tram organisation.

- 132 TfGM said that the publication of the risk profile had allowed it to identify the top hazards on the network and to instigate reviews of the relevant risks and controls. This included a joint review with KAM of SPAS risk. In June 2019, the joint TfGM-KAM Operational Incident Reduction group (OIRG) established a SPAS reduction action plan to address arising issues in areas such as training, driver guidance and signalling issues and fatigue. A revised SPAS/SPAD strategy has not been developed by the group. Evidence provided by KAM showed that SPAS/SPAD numbers were decreasing and below the targets set by the joint business plan (paragraph 117).
- 133 TfGM stated that this review of risks also led to a re-organisation by KAM of driver management structures. This was intended to allow more effective management and assessment of drivers. KAM are additionally revising the competence management system and operating rules for drivers and other roles on the network. One of the objectives of this project is that all elements of competence management, including selection and training, will be based on risk assessments of the tasks being undertaken. KAM is working with other light rail and mainline railway companies to understand how they can train and assess driver skills and develop a 'just culture' approach to investigating operating incidents.
- 134 As a result of the review, KAM also issued a revised work instruction dealing with fatigue management in February 2020. This work instruction was supported by internal briefing documents on various aspects of fatigue management and a toolbox talk for staff, which discussed personal strategies to avoid sleep debt.²¹
- 135 In March 2020, the Office of Rail and Road (ORR) reported that it considers that this recommendation has the status of 'Implementation ongoing'. For this reason, a further recommendation has not been made.

Recommendation 4

- 136 This recommendation reads as follows:

UK tram operators, owners and infrastructure managers should work together to research and evaluate systems capable of reliably detecting driver attention state and initiating appropriate automatic responses if a low level of alertness is identified. Such responses might include an alarm to alert the tram driver and/or the application of the tram brakes.

The research and evaluation should include considering use of in-cab CCTV to facilitate the investigation of incidents.

If found to be effective, a time-bound plan should be developed for such devices to be introduced onto UK tramways.

- 137 TfGM stated that it was working with UK Tram to review the status of technology which is capable of monitoring driver attentiveness via facial analysis. It was also discussing with its suppliers a specific proposal for a driver vigilance device and expected to confirm the requirements for this system in the first half of 2020.

²¹ Fatigue risk management was the subject of a recommendation in RAIB's report into the overturning of a tram at Sandilands junction, although this recommendation was not addressed to KAM or TfGM.

- 138 TfGM stated that it was currently undertaking a trial of an automatic vehicle speed monitoring system in response to recommendation 3 of the same RAIB report. While this would not have prevented the incident on 17 May 2019 (as the tram's speed stayed within the relevant limits throughout the driver's loss of awareness) it may reduce the risk resulting from a driver experiencing a loss of awareness in other circumstances, such as during the incident at Abraham Moss in October 2019 (paragraph 123).
- 139 In March 2020, ORR stated that LRSSB had published a report on systems with the capability to monitor driver attentiveness. This report had concluded that three systems performed reasonably well under normal operating conditions, although none currently offered the capability to be linked to a tram's braking system. In parallel to this research, tramway systems have or are investigating solutions specific to their own networks. In the opinion of ORR, this approach is resulting in positive action to improve the management of risk where driver actions are a key control, including the refining of existing driver vigilance systems.
- 140 ORR stated that it continues to discuss with tramway operators the timing for implementing actions relevant to this recommendation. ORR also stated that, while it recognises that emerging technologies intended to monitor driver attentiveness offer potential benefits, they may also present new risks that could reduce those benefits if the change is not properly controlled. ORR considers that the balance of these costs and benefits is currently unquantified. ORR considered that this recommendation has the status of 'Implementation ongoing'. For this reason, a further recommendation is not made.

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

- 141 In February 2020 KAM issued updated medical criteria for safety critical staff working on the Metrolink network.
- 142 In late 2019 KAM produced supplements to some operational risk assessments which had been prepared for the approval of new junctions into service. These supplements assessed the risk of a tram driver being unable to respond to visual signals as they approached the junction concerned. Risk controls were identified, and a conclusion drawn as to whether the risks were sufficiently controlled. TfGM stated that the findings of these assessments are recorded on the network hazard log and that it will ensure that appropriate actions are taken to control the risks identified.
- 143 In February 2020, TfGM's Metrolink engineering manager issued a safety assurance alert. This alert requires any future operational risk assessments to consider the hazard of a driver being incapacitated and unable to react to visual indicators but being able to continue to depress the TBC. This alert also requires project assurance processes to demonstrate that this hazard has been adequately addressed, prior to assets entering service in the future.
- 144 In June 2020, KAM issued a policy which sets out how its employees may make protected disclosures (commonly termed 'whistleblowing'),²² including how these may be made anonymously to an independent organisation.

²² Where a person discloses something that relates to a malpractice in the workplace in the reasonable belief that doing so is in the public interest. Malpractice includes risks to health and safety.

Recommendations

145 The following recommendations are made:²³

- 1 *The intent of this recommendation is that Keolis Amey Metrolink should reduce the risk of trams passing signals at danger or stop.*

Keolis Amey Metrolink should review, update and re-implement its strategy for managing the risk of trams passing signals at danger or stop. The revised strategy should include consideration of:

- the causes of signals passed at danger and stop (including loss of attention)
- how the risk of passing signals at danger or stop can be controlled and reduced, including the possible role of future technologies
- the network's current service patterns, vehicles, equipment and infrastructure and any changes proposed in these areas
- how this strategy will encourage the reporting of safety incidents and ensure the investigation of incidents and the management of staff involved in them are based on and promote the principles of just culture
- how this strategy will be supported by a wider understanding of risk across the network
- how senior managers will exercise assurance and provide safety leadership in this area
- arrangements for regular review and update of the strategy.

(paragraphs 126a and 128c)

²³ Those identified in the recommendations have a general and ongoing obligation to comply with health and safety legislation and need to take these recommendations into account in ensuring the safety of their employees and others.

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

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

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

The following recommendations relate to factors that were not causal to the incident, but which address safety issues identified during the investigation.

- 2 *The intent of this recommendation is that Keolis Amey Metrolink has driver medical fitness requirements that are based on an understanding of the risks of the driving task.*

Keolis Amey Metrolink should review its revised medical fitness criteria for tram drivers to confirm that they effectively control the risk of the driving task. This review should be based on an assessment of tram driver work activities, the associated risk and the available risk controls. It should consider relevant law, guidance and good practice from other industries that may be applicable.

If necessary, Keolis Amey Metrolink should produce an updated medical fitness requirement for tram drivers and make changes to the associated driver assessment arrangements (paragraph 128a).

- 3 *The intent of this recommendation is that Keolis Amey Metrolink should appropriately and effectively address the risk of fatigue.*

Keolis Amey Metrolink should review and improve its current fatigue risk management system for safety critical staff to confirm that it meets relevant industry guidance and best practice. This review should be based on an assessment of work activities and their associated risks and available risk controls. The review should consider relevant law, guidance and practice (paragraph 128b).

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