RAIB

Rail Accident Investigation Branch

Rail Accident Report

Collision between a tram and a cyclist, near Audenshaw tram stop, Manchester 1 September 2021

Report 08/2022
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This investigation was carried out in accordance with:

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

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Preface

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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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Contents

Preface 3
Summary 7
Introduction 8
Definitions 8
The accident 9
Summary of the accident 9
Context 10
The sequence of events 14
Background information 17
Analysis 27
Identification of the immediate cause 27
Identification of causal factors 27
Identification of underlying factor 30
Observations 41
Previous occurrences of a similar character 43
Summary of conclusions 44
Immediate cause 44
Causal factors 44
Underlying factors 44
Additional observations 44
Previous RAIB recommendations relevant to this investigation 45
Recommendations and learning point 47
Recommendations 47
Learning point 49
Appendices 50
Appendix A - Glossary of abbreviations and acronyms 50
Appendix B - Investigation details 51
Appendix C - Chronology of dates and activities referenced in this report 52

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Summary

At 19:25 hrs on Wednesday 1 September 2021, a child riding a bicycle was involved in a collision with a tram on the Metrolink system in Manchester. The collision occurred at a signal-controlled pedestrian crossing located at the junction of Droylsden Road and Kershaw Lane. The tram was travelling westbound, on a journey from Ashton-under-Lyne towards Manchester city centre. The cyclist suffered serious injuries in the collision.

The cyclist had been waiting at a pedestrian refuge positioned in Droylsden Road. The positioning of this refuge is unusual; despite being located mid-carriageway, users still need to be aware that traffic may approach from either direction when making a decision to cross. RAIB's investigation concluded that the cyclist, who did not await the Puffin crossing indication that the road was safe to cross, was probably focused on eastbound road traffic and he may have been unaware of the westbound tram's approach at the moment when he stepped from the pedestrian refuge.

An underlying factor was that the risk assessment processes applied during the design, construction and opening of the East Manchester Line did not identify the hazard to pedestrians created by the crossing layout until the tramway construction was advanced to a point where the design could not be easily changed.

RAIB has made five recommendations. The first is that Transport for Greater Manchester (TfGM) and Tameside Metropolitan Borough Council (TMBC) should review the layout of the crossing in light of this accident. The second recommendation is that TfGM should review its safety management system to ensure that adequate processes are in place, both within TfGM and within contractors employed by TfGM, to identify hazards and control risks at the design stage of tramway projects. The third recommendation is that the Light Rail Safety and Standards Board (LRSSB) review the application of road safety audits as a means to identify and mitigate hazards during tramway development and construction projects. The fourth recommendation is that Keolis Amey Metrolink (KAM) should review the operational risk assessments covering the operation of trams across the Metrolink network for completeness and adequacy. The fifth recommendation is that TfGM and KAM review the reliability, operation and maintenance of the sanding systems and CCTV systems on M5000 trams.

RAIB also identified a learning point, which reminds duty holders of the importance of ensuring the transfer of corporate memory, including documentation and records, during organisational change.

Introduction

Definitions

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

2 The report contains abbreviations. These are explained in appendix A. Sources of evidence used in the investigation are listed in appendix B. A chronology of events during the development of the Metrolink East Manchester Line is in appendix C.

The accident

Summary of the accident

3 At 19:25 hrs on Wednesday 1 September 2021, a child cyclist (aged 11 at the time of the accident, and hereafter referred to as 'the cyclist') was involved in a collision with a tram on the Metrolink system in Manchester. The collision occurred at a pedestrian crossing located at the junction of Droylsden Road and Kershaw Lane (figure 1). The tramway is integrated with Droylsden Road in the area of the accident.

4 The cyclist suffered serious injuries in the collision.

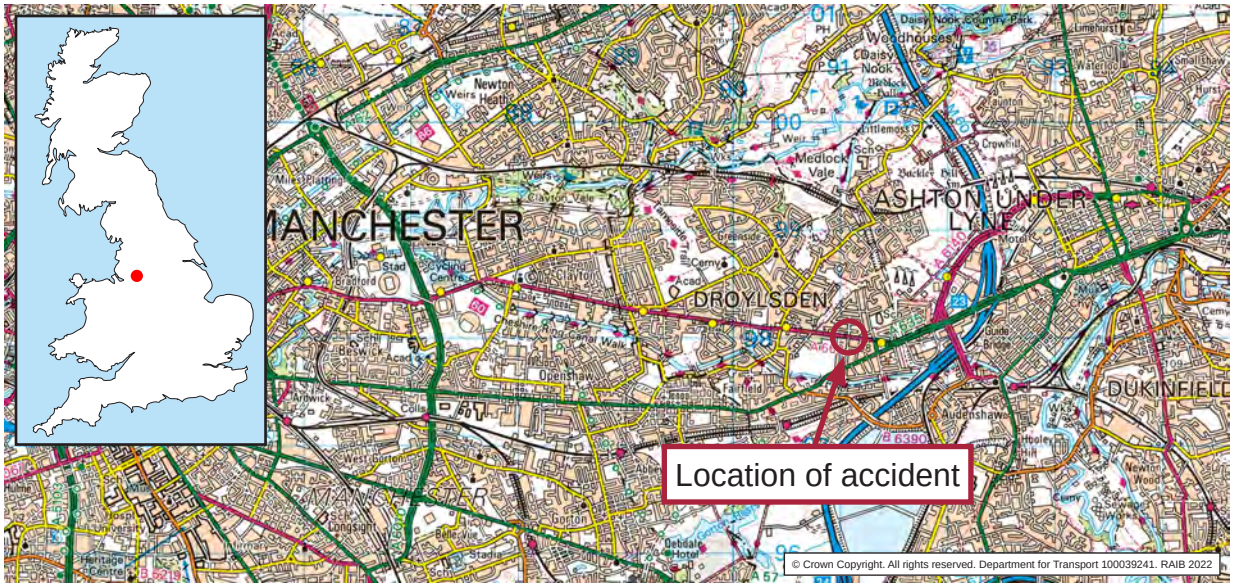

Figure 1: Extract from Ordnance Survey map showing location of accident

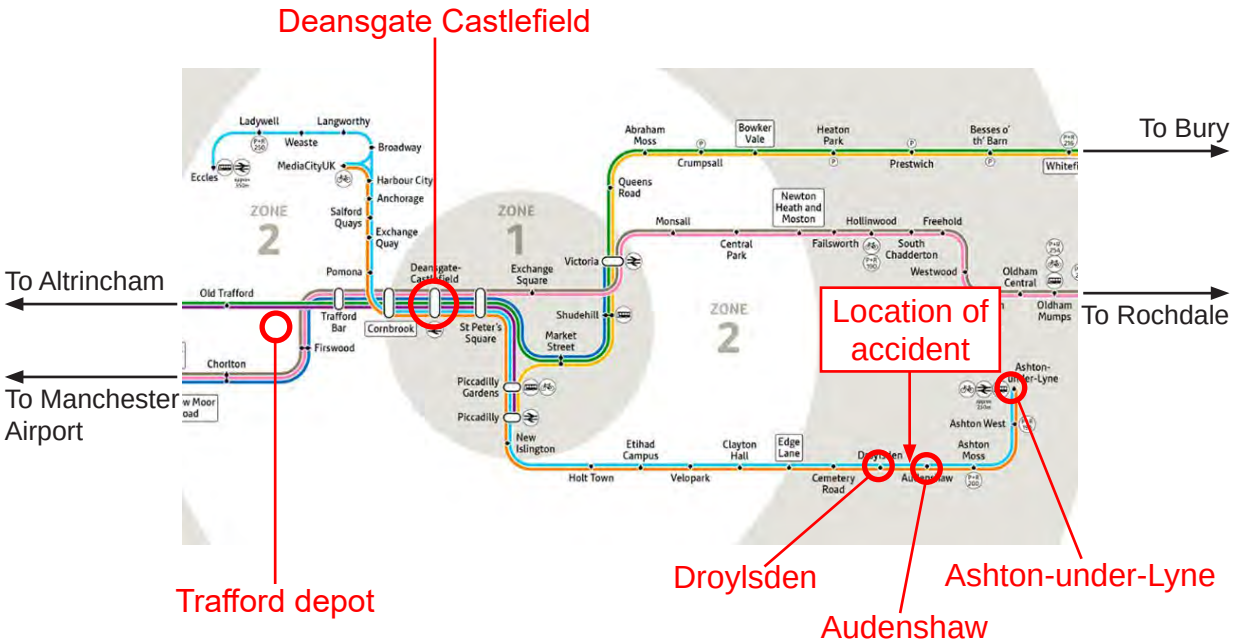

Figure 2: Metrolink map

Context

Location

5 The road junction between Droylsden Road and Kershaw Lane is located on the East Manchester Line of the Metrolink system. This line runs from Manchester city centre eastwards to a terminus at Ashton-under-Lyne (figure 2). The pedestrian crossing, located slightly to the west of the road junction, is situated 4.7 miles (7.6 km) from a datum point located at Piccadilly Gardens in Manchester city centre.

6 Between Clayton Hall and Audenshaw tram stops (figure 2), the tramway is integrated into the carriageway of the A662 Droylsden Road.[1] This means that trams share the road, with some restrictions, with other users (such as other road vehicles, cyclists and pedestrians).

7 At such locations, trams are subject to the same legislation and regulations as other road users, although tram operators may choose to apply more restrictive criteria to tram operations, such as lower speed limits. However, trams are controlled at junctions (and road crossings) by a set of traffic signal indications specifically and exclusively intended for them. These tram-specific signals are interlinked to the road traffic signals and pedestrian indicators which govern the actions of other road users.

8 In the area between Audenshaw and Droylsden tram stops, trams travelling eastbound (from Manchester city centre towards Ashton-under-Lyne) share the carriageway with all other road users travelling in the same direction. Westbound trams use a section of the carriageway from which other vehicles are prohibited; this prohibition is indicated by signage and by the tram section of the carriageway being painted red. Westbound road vehicles use the remaining section of the carriageway (figure 3). From north to south, the areas of the road are:

- eastbound trams and other road users
- westbound trams only
- westbound other road users, no trams.

9 To assist pedestrians in crossing Droylsden Road safely, a Puffin[2] crossing is provided at the western arm of the junction with Kershaw Lane (figure 4). Puffin crossings are controlled by pedestrians. Crossing users operate a demand button, and then await a ‘green walking man’ indication (signifying ‘Cross with care’[3]) before crossing. Puffin crossings are characterised by having the ‘green walking man’ and ‘red standing man’ (signifying ‘Do not start to cross’) indications located adjacent to the demand buttons.[4] Puffin crossings are also provided across the northern and southern sections of Kershaw Lane, adjacent to Droylsden Road.

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[1] To the west of Droylsden tram stop (figure 2), the A662 is referred to as Manchester Road, and then Ashton New Road when closer to Manchester city centre.

[2] A definition of a ‘Puffin’ crossing, with associated references, can be found in Chapter 6 of the UK ‘Traffic Signs Manual’. This defines a Puffin crossing as ‘a pedestrian crossing using nearside light signals’.

[3] Highway Code, 2022 edition, rule 21.

[4] The older ‘Pelican’ crossings have the ‘red standing man’ and ‘green walking man’ indications on the far side of the crossing, such that a user looks across the carriageway to see those indications.

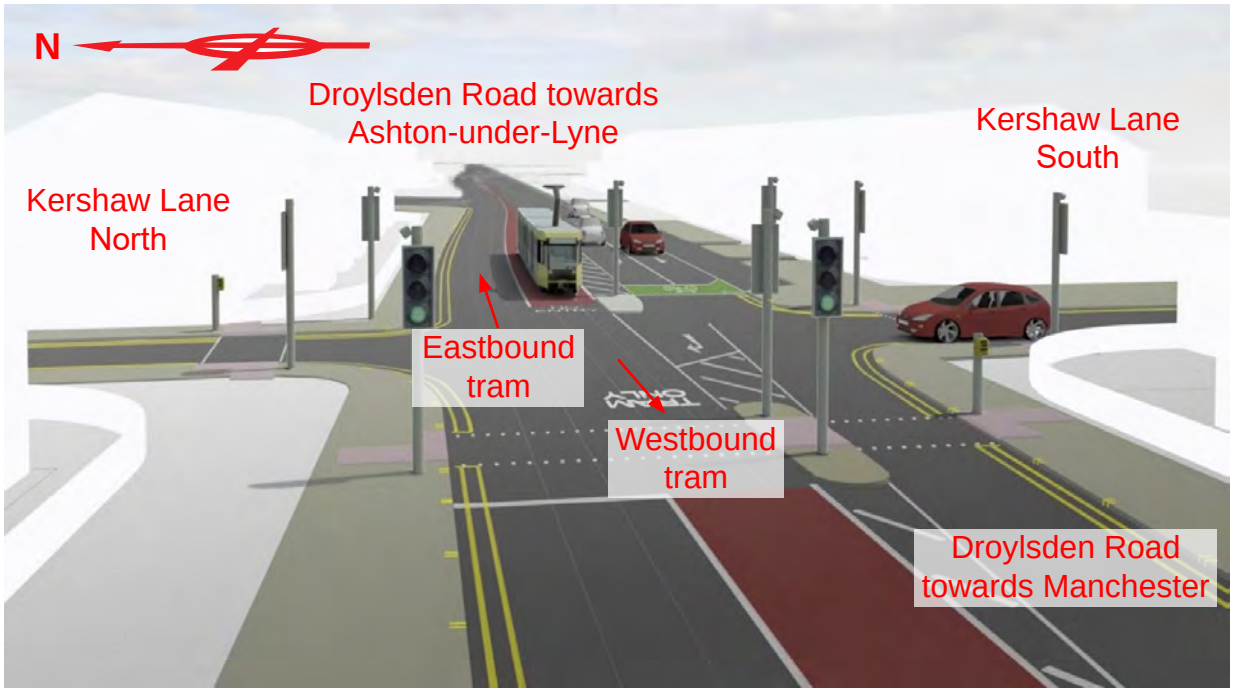

Figure 3: graphical representation of the junction layout, looking east (courtesy of TfGM)

Figure 4: general view of the Puffin crossing across Droylsden Road (looking east), with (inset) demand box showing 'red standing man' indication

10 The crossing at the western arm of the junction with Kershaw Lane is provided with a mid-carriageway pedestrian refuge. The refuge, protected by high containment kerbs, is located between the road for westbound vehicles and the track for westbound trams (figures 3 and 4). The refuge also provides a location for traffic signals.

11 Although a mid-carriageway pedestrian refuge exists, the Puffin crossing covers the entire carriageway of Droylsden Road as a single crossing. Operating the demand button on either side of the crossing will cause road (and tram) signals to change, stopping traffic from both directions so that an individual may cross the complete width of Droylsden Road.

12 Puffin crossing demand buttons are also provided at the mid-carriageway pedestrian refuge (figure 4). Their purpose is to aid users who may find themselves stranded at the refuge when the crossing time expires and road traffic is authorised (by the traffic signals) to proceed.

13 A convenience store is located on the south side of Droylsden Road, slightly to the east of the junction with Kershaw Lane (figure 5).

14 At the eastern side of the junction, a mid-carriageway island provides a location for traffic signals. However, no controlled crossing for pedestrians exists on this eastern side of the junction.

Organisations involved

15 Keolis Amey Metrolink (KAM) has been responsible for the operation and maintenance of the Metrolink system since July 2017. It employs the tram driver. Before July 2017, Metrolink RATP Dev Ltd (MRDL) was responsible for the operation of the system.

16 M-Pact Thales (MPT) is a consortium of Volker Rail, Laing O'Rourke and Thales. MPT was responsible for the detailed design and construction of recent extensions and enhancements to the Metrolink system, and specifically the East Manchester Line. Until July 2017, MPT was also responsible for maintenance activities on the East Manchester Line. MPT's maintenance responsibility was limited on the highway to tramway infrastructure, which included overhead power line and poles, trackwork, platforms and associated stop equipment. From July 2017, these responsibilities were transferred from MPT to KAM.

17 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 is responsible for the letting and management of the contract to operate the system (with MRDL and then KAM). TfGM also let and managed the contract for the construction of the East Manchester Line to MPT. Before 1 April 2011, the responsibilities of TfGM were carried by the Greater Manchester Passenger Transport Executive (GMPTE).

18 The Manchester Urban Traffic Control (UTC) is responsible for the management of the traffic lights at the pedestrian crossing; UTC is part of the TfGM organisation.

19 Tameside Metropolitan Borough Council (Tameside MBC) is the local authority and as the Local Highways Authority (LHA) it is responsible for both Droylsden Road and Kershaw Lane. As the LHA it is responsible for the maintenance of the road, including the mid-carriageway pedestrian refuge at the accident location. Although Tameside MBC is responsible for the road and associated infrastructure, it is not responsible for the maintenance of equipment (such as track and overhead power lines) which are specific to the operation of the Metrolink system.

20 All of these organisations freely co-operated with the investigation.

Tram involved

21 The tram involved was a Bombardier M5000 vehicle (figure 6) number 3073. The 'B' end of the tram was leading at the time of the accident.

22 The design of the tram played no part in the accident. Defects in the operation of the sanding system and the CCTV system are discussed at paragraphs 170 and 173.

Staff involved

23 The tram driver joined Metrolink in April 2014 and completed his training later that year. He held all the necessary competency certification for his role, and all his competency assessments were up to date. None of his recent assessments had indicated any concerns about his competence or behaviours.

24 RAIB found no evidence of fatigue or any distractions affecting the driver's behaviour during the accident.

External circumstances

25 The weather at the time of the accident was dry and cloudy, with a temperature around 16°C recorded at a nearby weather station.[5] Sunset was at 19:58 hrs on that day, around half an hour after the accident. Neither the weather nor the ambient lighting conditions had any bearing on the accident.

[5] Data taken from readings at Manchester Airport, approximately 10 miles (16 km) from the accident location.

The sequence of events

Events preceding the accident

26 On the day of the accident, the driver booked on duty at 18:03 hrs at Metrolink's Trafford depot (figure 2). He then travelled as a tram passenger to Deansgate Castlefield where he took over tram 3073 from another driver. At 18:31 hrs, he left Deansgate Castlefield and drove the tram to Ashton-under-Lyne, arriving at 19:09 hrs. With the exception of a minor incident of anti-social behaviour, the journey to Ashton-under-Lyne was uneventful.

27 The driver changed ends, and at 19:17 hrs, the tram departed Ashton-under-Lyne on its return trip. The planned journey was to Eccles via Manchester city centre and Media City.

28 At 19:23 hrs, CCTV from the convenience store (paragraph 13, figure 5) shows the cyclist entering the shop on foot; he made a purchase and left the shop at 19:24 hrs.

29 After leaving the shop, the cyclist mounted his bicycle, crossed the southern leg of Kershaw Lane, and then moved around the road side of the pavement fencing (figure 5) at the south-west corner of the junction with Droylsden Road. The cyclist then crossed Droylsden Road as far as the mid-carriageway pedestrian refuge. CCTV shows that he arrived there at 19:25:31 hrs.

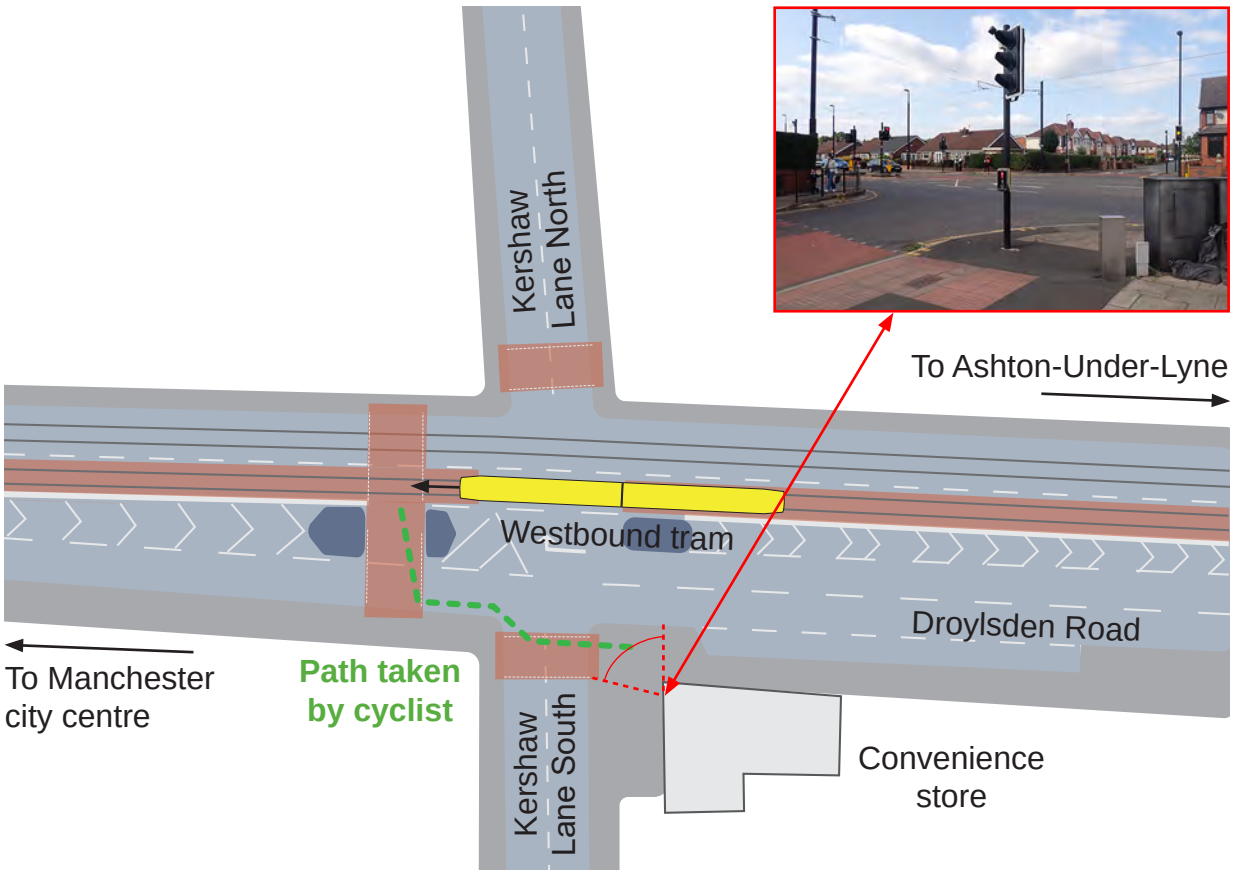

Figure 5: the crossing and the path taken by the cyclist to the mid-carriageway refuge

30 The driver of the approaching tram stated that he saw the cyclist at the pedestrian refuge but did not initially think that they were likely to move towards the tram. However, after waiting at the refuge for six seconds, the cyclist moved into the path of the approaching tram. At that point, the On-Tram Data Recorder (OTDR) showed that the tram was travelling at around 21 mph (33.9 km/h). In response to the cyclist moving into the path of the tram, the driver applied the tram's hazard brakes which also sounded the tram's street whistle. The OTDR also records the tram's street whistle being used very shortly before the brake application. After the hazard brake application, OTDR shows the driver sounding the tram's segregated horn. The horn sounding would have over-ridden the street whistle command. The collision occurred at an estimated speed of 17.3 mph (27.9 km/h), approximately one second after the hazard brakes had been applied.

31 The maximum speed recorded by the tram immediately before the accident is 21.7 mph (34.9 km/h). The permissible speed for westbound trams at this location is 20 mph (32.2 km/h). The speedometer fitted to the M5000 tram is an analogue device, and it is therefore difficult for the driver to detect small variations in speed. For this reason, KAM permits a margin of error of 4 mph when assessing speed compliance.

Events during the accident

32 The tram stopped approximately three seconds after the application of the hazard brake and 14 metres beyond the point of the collision.

Figure 6: The tram, stopped after the accident. The point of the collision is indicated

33 The cyclist was knocked from his bicycle and fell partly under the left-hand side of the tram. He was found alongside the tram, with his legs in the vicinity of the tram's centre bogie, which was in line with the pedestrian refuge by the time the tram came to a stop. There was no evidence that the cyclist interacted with the tram's underrun protector, which is located immediately in front of the leading wheels of the tram. This indicates that the cyclist fell to the left of the tram's bogies and wheels.

34 It is possible that the high containment kerb (figures 4 and 6) around the pedestrian refuge may have deflected the cyclist towards the tram after the collision. Marks were found on the kerb after the accident showing evidence of contacts, but it cannot be determined exactly what effect the presence of the kerb had on the outcome of the collision.

35 It is not known if the cyclist was wearing a helmet at the time of the accident. The CCTV from the convenience store shows that he was not wearing such a helmet when he was inside the store, and later CCTV is inconclusive.

Events following the accident

36 The driver immediately reported the accident to Metrolink's control, who called the emergency services. The cyclist was conveyed to hospital, where he was treated for his injuries.

37 There were no injuries to anyone on board the tram and the passengers were evacuated from the tram without incident.

38 The tram driver was subject to routine screening for the presence of drugs and alcohol. All tests returned a 'clear' result.

39 The tram was taken to the Metrolink depot at Queens Road, and was examined on 2 September by RAIB. The tram was subsequently further examined and tested by KAM, including testing of the tram's audible warnings (see paragraph 48).

40 Analysis by RAIB based on the tram's data recorder and site measurements showed that the tram achieved a retardation rate of 2.15 m/s^2 after the application of the hazard brake. This retardation rate is less than the 2.8 m/s^2 specified in the applicable standard[6] and in the manufacturer's documentation for the M5000 tram. This difference was most likely due to wheel slide, which the tram experienced during braking. This is further discussed in paragraph 170.

41 Had the tram achieved a retardation rate of 2.8 m/s^2, the speed of the tram at the point of collision would have been approximately 15.8 mph (25.5 km/h), around 1.5 mph (2.4 km/h) lower than actually occurred (paragraph 30). Analysis undertaken by RAIB shows that, due to the very short time between the application of the hazard brake and the collision, the cyclist would not have been able to move clear of the tram even if the tram had achieved this higher retardation rate. This means that the collision with the cyclist would still have occurred, but at a marginally lower speed. It cannot be stated with certainty what effect this reduction of speed would have had on the collision and the injuries inflicted on the cyclist.

[6] BS EN 13452-1:2003, Railway applications - Braking - Mass transit brake systems - Part 1: Performance requirements, section 6.2.2 table 3.

Background information

The Puffin crossing and its associated traffic signals

42 In common with other junctions provided with traffic lights, the traffic signals at this location work in ‘phases’; these are individual states of the traffic signals, which authorise movements by different road users, and for users approaching from different directions. During one of these phases, the Puffin pedestrian crossing ‘green walking man’ is exhibited across Kershaw Lane south, Droylsden Road and Kershaw Lane north with all other traffic signals at red.

43 The Manchester UTC advised RAIB that, at the time of the accident, there were no known faults with the traffic signals at the accident location.

44 Guidance on the design of pedestrian crossings is provided by LTN 2/95 ‘The Design of Pedestrian Crossings’.[7] Within this document, table 6 ‘Puffin crossings – operational cycle and timings’ states that the maximum waiting time for pedestrians should be 60 seconds. Testing by RAIB over a series of seven[8] crossing passages found the average waiting time for pedestrians at the crossing to be 32 seconds, with a maximum of 56 seconds.

Audible warnings produced by M5000 trams and their usage by drivers

45 The M5000 trams can produce two different audible warnings, known as a ‘street whistle’ and a ‘segregated horn’. The street whistle is intended for use in areas where the tram is running on-street or in areas where pedestrians can be expected (such as Manchester city centre). The segregated horn is intended for use in areas where the tram is operating on track where pedestrians and other vehicles are not expected to be. The segregated horn is louder than the street whistle, reflecting the generally higher speed of operation in such circumstances. Drivers may use either of the audible warning devices by operating the appropriate cab control.

46 There is no requirement in KAM’s rulebook[9] for drivers to sound an audible warning at every pedestrian crossing. The rulebook sets out a number of circumstances in which an audible warning should be sounded. These are:

- in accordance to fixed track side signs
- on approach to a crowded platform
- entering or leaving an enclosed area
- when passing another tram or high sided vehicle
- in an area of intense pedestrian activity

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[7] Local Transport Note 2/95 ‘The Design of Pedestrian Crossings’ dated April 1995. LTN 2/95 was withdrawn in 2019 and replaced by the Traffic Signs Manual, Chapter 6. LTN2/95 was the prevailing design guidance at the time of the design and construction of the crossing at Kershaw Lane. Although the scope of LTN 2/95 excluded signalled junctions (such as the accident location), it provided advice on the design of pedestrian crossings in general and the operation of signalled controlled crossings (such as Puffin crossings) in particular.

[8] An eighth test showed an extended pedestrian wait (1 minute 47 seconds) caused by two trams passing in the close vicinity of the crossing. This was not the case at the time of the accident; the tram which had departed from Droylsden (paragraph 82) was sufficiently far from the crossing to have no influence on the crossing operations. This extended wait was excluded from the calculation of average wait times.

[9] Rulebook as printed spring/summer 2020.

- setting off from a stand
- when entering a curve
- when a vehicle is blocking the track.

The rulebook further specifies that the segregated horn 'should not be used in the street running sections except for emergencies'. None of those circumstances applied to this accident, as the driver did not perceive that the pedestrian was likely to step from the refuge until immediately before the accident.

47 In the event that the tram hazard brake is deployed (as was the case in this accident, paragraph 30), the tram will automatically sound the street whistle. Tests carried out after the accident demonstrated that this occurred regardless of whether the driver was already operating the street whistle at the time. Tests also confirmed that the segregated horn will override the street whistle if commanded by the driver.

48 Following the accident, tram 3073's street whistle and segregated horn were tested by KAM, at the request of RAIB. The testing was carried out in accordance with the Light Rail Safety and Standards Board (LRSSB)[10] document 'LRG 5.0 - Tramway Audible Warnings Acoustic Test Guidance'. Although the LRSSB document (produced in 2020) post-dates the design and construction of the M5000 trams, it was found that the audible warnings produced by tram 3073 complied with the document.

The East Manchester Line of the Metrolink network

49 GMPTE built the Metrolink East Manchester Line in order to serve communities to the east of Manchester city centre. Appendix C provides a chronology of the development of the East Manchester Line and documents referenced in this report.

50 In 1994, GMPTE carried out a public consultation exercise to seek views on the East Manchester Line project from local stakeholders (such as Tameside MBC and residents). A concept drawing created for the purposes of that consultation (figure 7) shows the tramway laid within the existing carriageway of Droylsden Road. However, at that point, no details regarding track alignment (beyond incorporation of the track within the existing highway) or pedestrian crossings had been considered.

51 Before the construction of the East Manchester Line, the Droylsden Road/ Kershaw Lane junction did not have traffic signals. There were no controlled pedestrian crossings, and traffic movements such as right turns were permitted. A set of bollards and a small refuge was provided in the centre of the carriageway at the western side of the junction (figure 8), as part of an uncontrolled crossing route.

[10] The Light Rail Safety and Standards Board is the safety and standards body of the tramway sector. It is a subsidiary company of UKTram, with a separate governing body, an independent chair and a board comprising of industry representatives. Further information can be found at https://lrssb.org/.

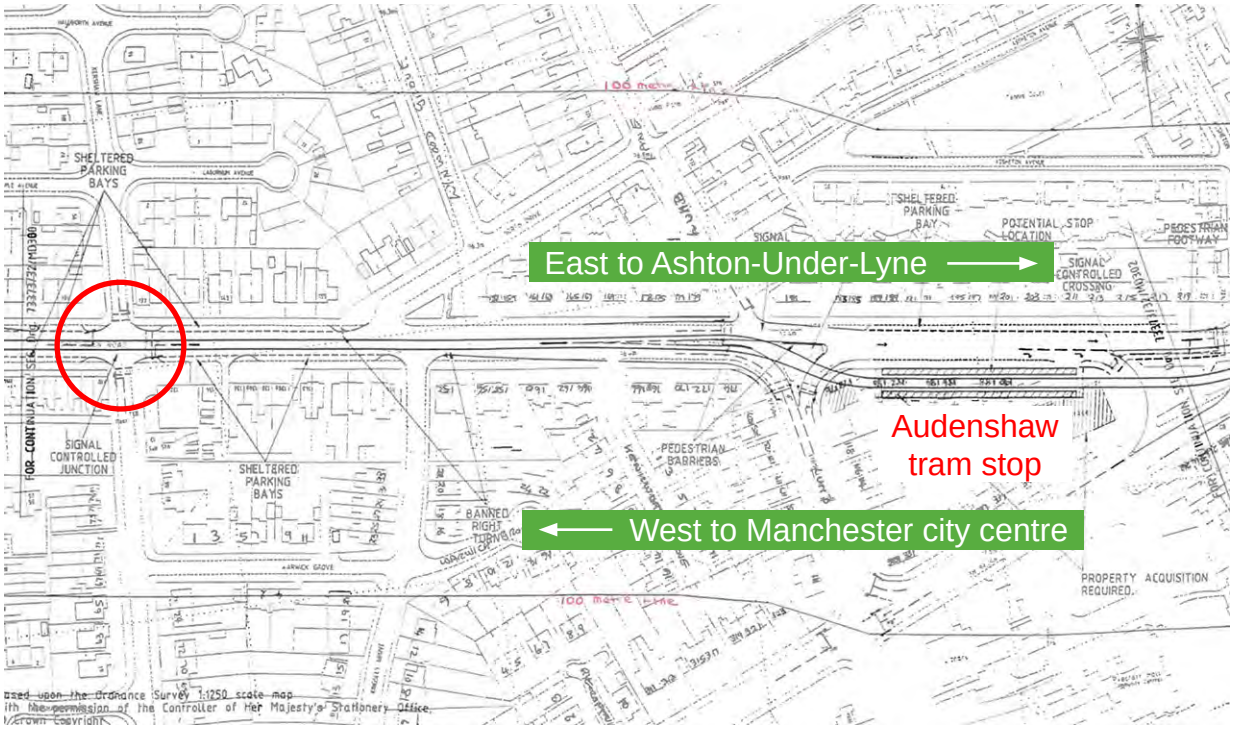

Figure 7: 1994 concept drawing (courtesy of TfGM)

Figure 8: Image taken in 2008 of the junction looking west, before the start of East Manchester Line works (courtesy Google Streetview)

52 Many potential problems had to be overcome when integrating the East Manchester Line with the existing road. These included ensuring, as far as possible, that trams could proceed unimpeded by other road users, and preventing obstruction to trams by other road vehicles turning right at junctions.

The Trambahn concept

53 It is preferable, when possible, to separate tram operation from other road users. This is to improve the reliability and speed of the tram operation by eliminating the risk of trams being impeded by the actions of other users. Such separation is mostly effective if other road users are discouraged from impinging on the area of the carriageway set aside for trams. The width of Droylsden Road is such that separation could only be achieved in one direction.

54 GMPTE's chosen concept design for the tramway along Droylsden Road was to prioritise westbound trams and provide separation for those trams from other road users. Eastbound trams, heading towards Ashton-under-Lyne, would share road space with other road users.

55 GMPTE's original intention was for westbound trams to be separated from other westbound road users by means of a 'Trambahn'.[11] As envisaged, the Trambahn would be raised by 75 mm above the general road surface, with angled kerbing separating the Trambahn from the surrounding area. At junctions and other locations where road traffic needed to cross the tramway, the Trambahn would descend to the general road level.

Right turns at the Droylsden Road/Kershaw Lane junction

56 Road users turning right across a general flow of traffic in the opposite direction need to stop and await a suitable opportunity to complete their turn. This stopped traffic can impede the passage of a tram in locations where the tramway is integrated with the roadway. One option to manage this issue is to prohibit such turns. However, such prohibitions must be balanced against the needs of local residents and businesses who require access to residences and other premises.

57 In the case of the East Manchester Line, a Transport and Works Act Order was obtained in 1998 (Statutory Instrument 1998/1936[12]). Schedule 9 part 3 of this Order prohibited vehicles travelling eastbound on Droylsden Road from turning right into the southern leg of Kershaw Lane. However, the order did not change the arrangements for vehicles travelling westbound and turning right into Kershaw Lane north so a right turn lane at the junction was still required.

The combination of Trambahn and the right turn lane at the Droylsden Road/Kershaw Lane junction

58 Despite the problems caused by right-turning road traffic (paragraph 56), design solutions are available. For example, at a location approximately 0.5 mile (0.8 km) to the west of the accident location, the two tramway tracks are integrated with the road traffic in each direction, with right turn lanes being placed between the tramway tracks in the centre of the road (figure 9).

59 However, such a layout is incompatible with the Trambahn concept. Placing the right turn lane between the tramway tracks would have meant the loss of a considerable length of the Trambahn, and therefore the loss of many of the benefits of the concept.

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[11] 'Trambahn' was a term used during the Metrolink expansion project to describe a section of tramway which was within the boundaries of a road carriageway, but from which vehicles other than trams were prohibited.

[12] See https://www.legislation.gov.uk/uksi/1998/1936/contents/made.

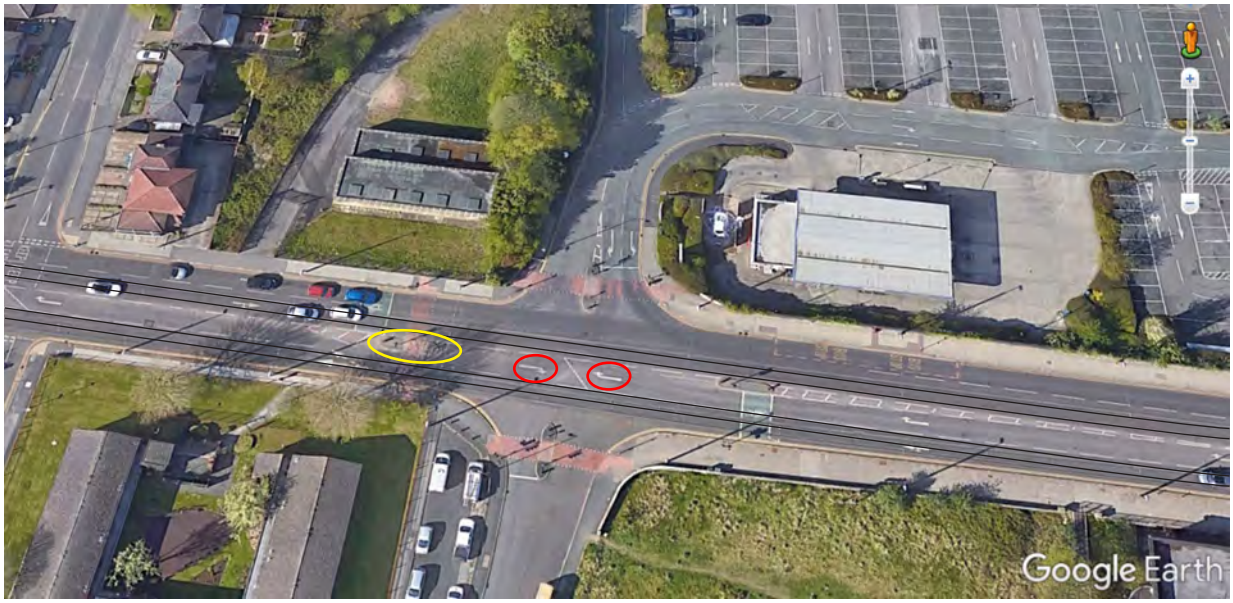

Figure 9: Right turn lanes (highlighted red) positioned between tramway tracks, with pedestrian refuge (highlighted yellow) positioned in the centre of the carriageway

The controlled crossings and the final outline design

60 The addition of the tramway to the existing Droylsden Road led to the remodelling of the Kershaw Lane junction and conversion to a junction controlled by traffic signals. This included the provision of controlled pedestrian crossings to allow users to cross the roads safely.

61 During 2008 and 2009, designers working on behalf of GMPTE developed a layout for the Droylsden Road/Kershaw Lane junction which showed the two tram tracks slewed to the north side of the Droylsden Road carriageway. It was recognised that the optimum location for a pedestrian crossing (the 'desire line') was at the eastern leg of the junction as this is the same side of the junction as the convenience store (and other local businesses).

62 As such, the outline design (figure 10) included the following features:

- Trambahn for the westbound trams
- tracks slewed to the north across the junction
- right turn lane for westbound road vehicles wishing to access Kershaw Lane north
- controlled crossings of all four legs of the junction - Kershaw Lane north, Kershaw Lane south and Droylsden Road to both the east and the west of the junction.

63 The design produced on behalf of GMPTE was an outline design. It did not include details such as the provision (or otherwise) of a pedestrian refuge at the crossings of Droylsden Road (or details of any similar refuges). The design also omitted considerations such as parking bays and junction stop lines.

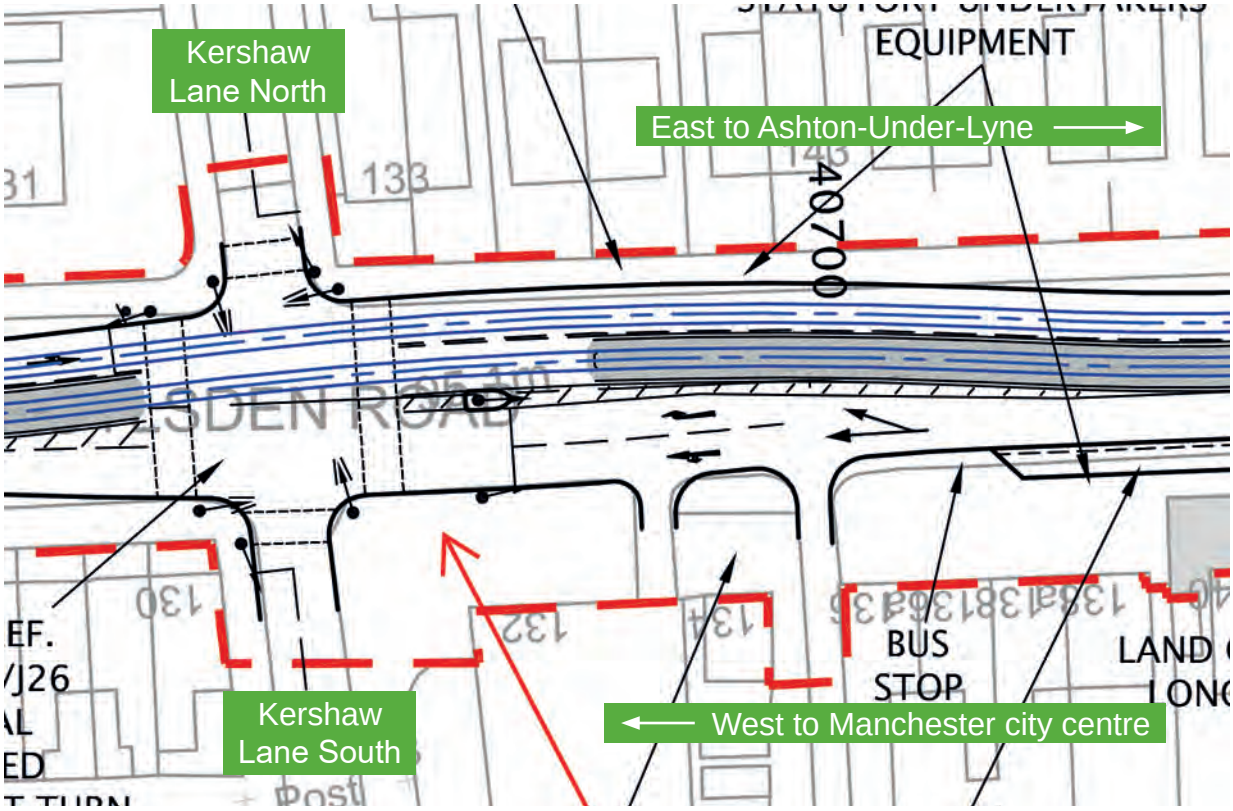

Figure 10: GMPTE-developed outline design, dated January 2010 (Trambahn indicated by areas of tram track shaded grey) (courtesy of TfGM)

The contract with MPT and the creation of the detailed design

64 During 2010, GMPTE entered into a contract with MPT which included the construction of the East Manchester Line. GMPTE provided the outline design to MPT. MPT was then responsible for the detailed design work, construction and (until July 2017) the maintenance of the East Manchester Line.

65 In April 2010, an initial design (figure 11) for the layout at Kershaw Lane had been prepared which included a pedestrian refuge at the eastern side of the junction, this refuge being positioned to the south of the tram tracks. In this design, the western side of the junction (the location of the accident) was shown as a controlled crossing with no pedestrian refuge.

66 This initial design had the advantage of placing a controlled crossing at the location of the likely 'desire line' for pedestrians crossing to and from the convenience store and other businesses at the eastern side of the junction (paragraph 61). However, problems associated with the needs of property owners in the vicinity were encountered with the layout. For these reasons, this initial design was rejected. Design work then progressed with the intent of providing a controlled crossing (on Droylsden Road) solely across the western leg of the junction. By June 2010, MPT's detailed design had progressed to a point where it included the pedestrian refuge in its final position, to the south of both tram tracks. It was this configuration which was ultimately constructed, and which existed at the time of the accident (figure 12).

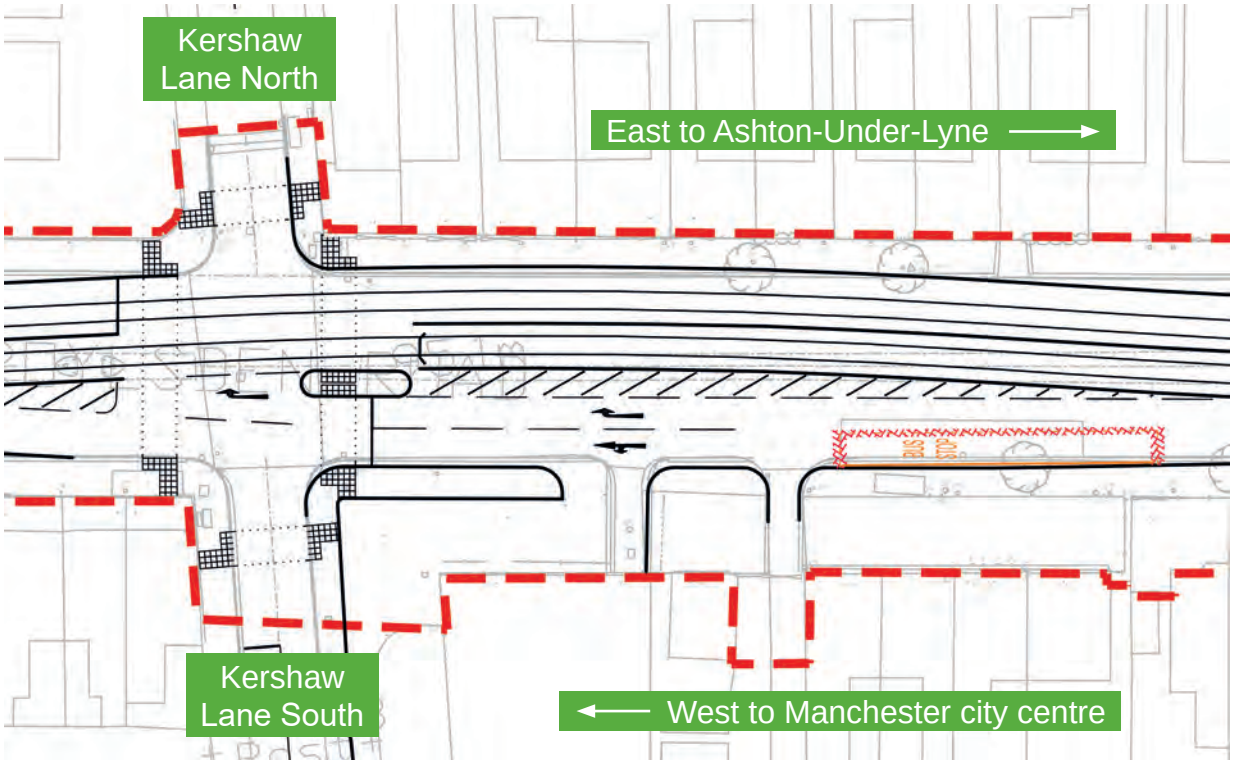

Figure 11: April 2010 initial design (courtesy of TfGM/MPT)

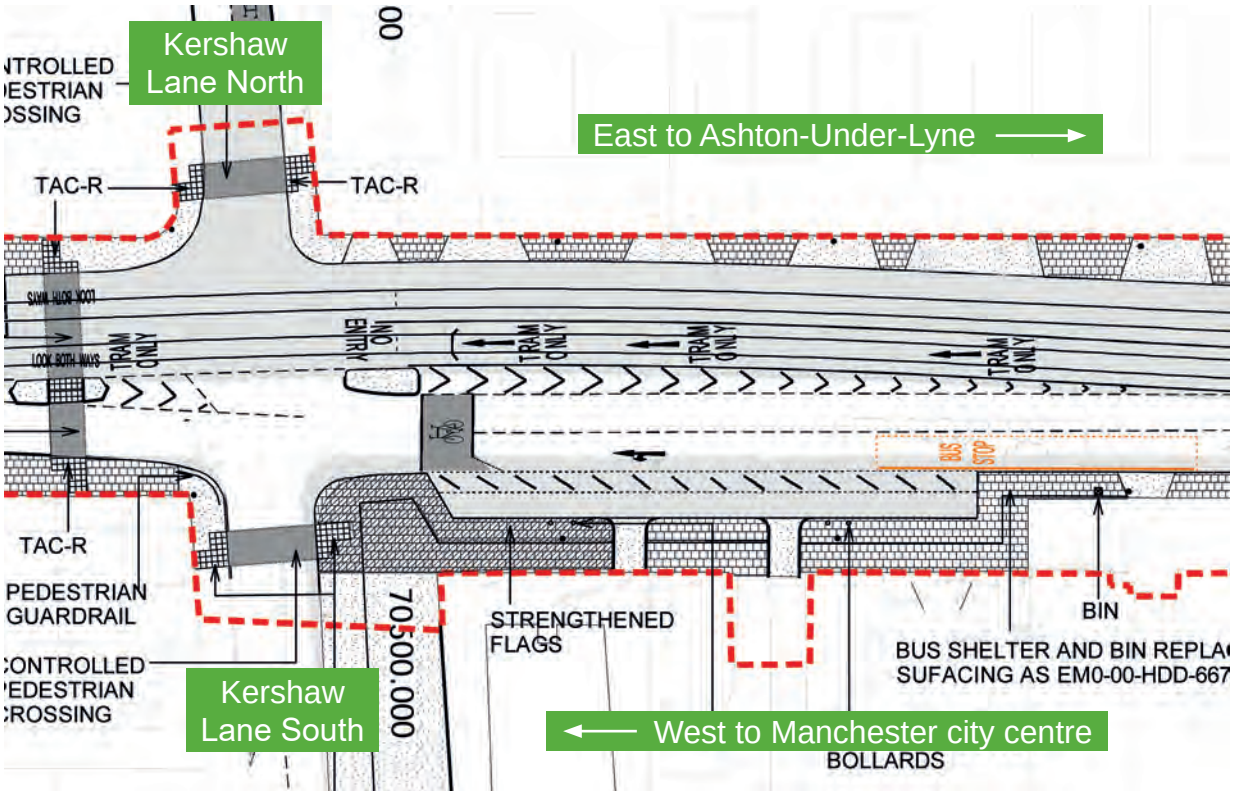

Figure 12: June 2010 design (courtesy of TfGM/MPT)

67 MPT provided GMPTE with a commentary on the outline design (paragraph 63) in July 2010. This document[13] stated that '*The original design included pedestrian crossing facilities on all arms of the junction. However, the pedestrian facility across the eastern arm of Droylsden Road was subsequently omitted due to interface issues with adjacent driveways on the northeast side of the junction'* and '*Within the limited cross section available, the design incorporates a pedestrian refuge island across the western arm of Droylsden Road which will incorporate secondary signalling equipment for the right turn manoeuvre towards Kershaw Lane (N)*'.

The end of the Trambahn concept, construction and opening of the tramway

68 Local stakeholders, including Tameside MBC, raised concerns about the layout of the tramway in the area and the Trambahn concept in general. These concerns included issues with residents accessing driveways and anticipated problems with unloading delivery vehicles at the convenience store and other businesses. In September 2011, TfGM requested MPT to prepare an alternative layout. In response, MPT prepared a concept design (figure 13) which showed a layout with westbound trams sharing the right turn lane. This layout placed the pedestrian refuge between the tram tracks. However, this layout was later rejected. The reasons for the rejection are discussed at paragraph 107.

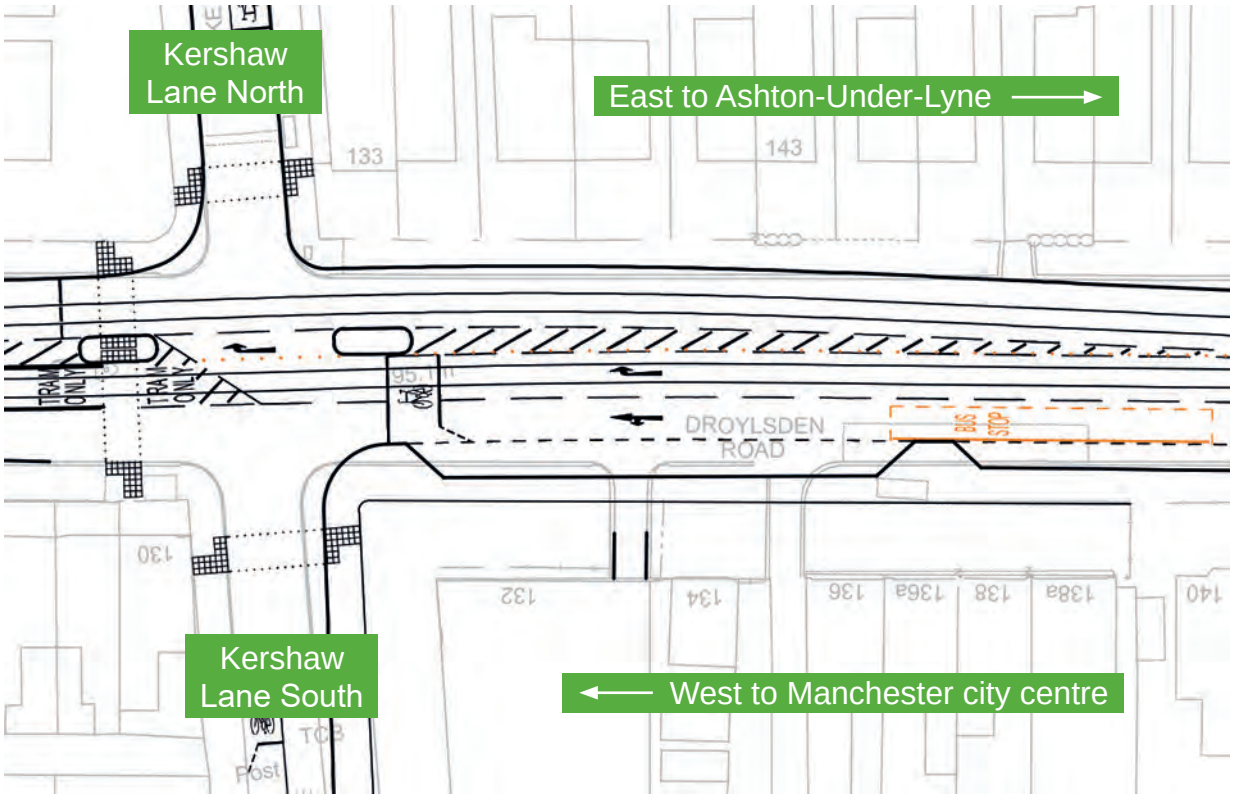

Figure 13: September 2011 concept design (courtesy of TfGM/MPT)

[13] Document reference MPT3B-EMO-00-ZRP-600.

69 In December 2011, TfGM took the decision to abandon Trambahn and replace it with a 'flush reserved tram lane' (FRTL). An FRTL, like Trambahn, is an area of the road within which only trams are permitted to operate. The key difference between FRTL and Trambahn is that FRTL is at the same road level as the surrounding carriageway, with the tram rails installed so that they are flush with the surrounding surface (unlike a Trambahn, paragraph 55). General road users are discouraged from using FRTL areas by measures such as signage and painting the surface of the FRTL in a contrasting (red) colour to indicate that only trams are permitted to operate within the FRTL area.

70 Construction of the tramway took place during 2011 and 2012. The basic track foundations were completed by November 2011 (figure 14), and the tramway works area around the location of the accident were substantially completed by the end of 2012. The East Manchester Line was opened from central Manchester to Droylsden in February 2013, and from Droylsden, past the location of the accident, to Ashton-under-Lyne in October 2013.

Figure 14: Construction work on Droylsden Road in November 2011. The location of the accident is at the right of the image (courtesy of TfGM)

The role of the Safety Authority

71 In Great Britain, the Office of Rail and Road (ORR) is the safety authority for tramway systems such as Metrolink. As the safety authority, ORR works to maintain and improve safety by ensuring that tramways comply with the relevant law, regulations, and codes of practice. 'The Railways and Other Guided Transport Systems (Safety) Regulations 2006' (ROGS) requires tramway operators and infrastructure managers to have a safety management system that is capable of controlling all the risks arising from the transport system they are operating or managing.

72 ROGS also covers projects such as the creation of the East Manchester Line. For such projects, ROGS requires the relevant companies to apply a 'risk and difference' test. This test has two elements:

- Does the project generate a significant new risk or an increase in risk?
- Is the technology new, or new to the transport system? In the context of the East Manchester Line project, the 'transport system' is the wider Metrolink network.

73 If the answer to both questions is 'yes', then a safety verification process must be followed. This process, which is described in ORR guidance,[14] involves the appointment of an 'Independent Competent Person' (ICP), who devises and carries out the Safety Verification, mainly by checking the adequacies of the arrangements being put in place.

74 If the answer to either question is 'no', then the safety of the project is managed in accordance with the processes described within the safety management systems of the companies involved. In the context of the East Manchester Line project, the safety management systems of both GMPTE (later TfGM, responsible for the tramway infrastructure and for the management of the contract with MPT) and MRDL (responsible for the operation of the tram service and replaced by KAM from July 2017) would have been responsible for managing the project's safety under ROGS.

75 It is good practice for the risk and difference test to be applied as early as practicable during a project. This is because the early involvement of the reviewer (being the ICP or a person appointed under the safety management system arrangements) may help identify issues which are relatively simple to amend at the design stage, but which may be more difficult (and expensive) to change once construction has started. In the case of the East Manchester Line project, no ICP was appointed. The reasons for this are discussed at paragraph 141.

76 In accordance with the principles of ROGS, ORR has no formal 'approval' role in the construction of tramways, even if Safety Verification is required. ORR advised RAIB that it had had no formal dealings with the team developing and constructing the East Manchester Line.

[14] See https://www.orr.gov.uk/guidance-compliance/rail/health-safety/laws/rogs/safety-verification-non-mainline-transport-operators.

Analysis

Identification of the immediate cause

77 The cyclist moved into the road immediately in front of the approaching tram.

78 Witness and CCTV evidence shows that the cyclist moved into the path of the approaching tram very shortly before the collision. The tram driver sounded a warning and then applied the hazard brake very shortly afterwards. The driver reported that the cyclist turned his head towards the tram, in apparent response to the warning. However, there was insufficient time for the cyclist to move clear of the tram or for the brakes to reduce the speed of the tram to prevent the collision occurring.

79 There is no evidence that the cyclist was wearing headphones or had any medical impairment which would have prevented him hearing the warnings produced by the tram (paragraphs 30 and 45 to 48). Although no data is available on ambient noise levels at the time of the accident, it is probable that the cyclist would have been able to hear the audible warnings sounded by the tram as it approached the crossing.

Identification of causal factors

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

a. The cyclist's attention was probably focused on eastbound road traffic, so he may have been unaware of the tram's approach from the opposite direction (paragraph 81).

b. The cyclist did not await the Puffin crossing indication that the road was safe to cross (paragraph 89).

Each of these factors is now considered in turn.

The design and layout of the crossing

81 The cyclist's attention was probably focused on eastbound road traffic, so he may have been unaware of the tram's approach from the opposite direction.

82 Analysis of the CCTV footage from the convenience store and from another tram which, at the time of the accident, had just left Droylsden tram stop (to the west of the accident location, figure 2) showed that a group of road vehicles was travelling eastbound on Droylsden Road in the vicinity of the Kershaw Lane junction immediately before the accident.

83 Witness evidence indicated that the cyclist was probably focused on these vehicles during the six seconds between his arrival at the pedestrian refuge and when he stepped into the path of the westbound tram.

The mid-carriageway pedestrian refuge

84 The location of the pedestrian refuge at this location is unusual. Pedestrian refuges are normally provided at the centre of a road crossing. Such a refuge allows the crossing user to complete the crossing of a traffic flow in one direction (typically traffic flowing from right to left, from the perspective of the crossing user) before crossing traffic flowing in the opposite direction (left to right).

85 The positioning of the refuge at the Kershaw Lane crossing does not follow this pattern. Eastbound trams and eastbound road vehicles travelling on Droylsden Road share a single lane. However, westbound road vehicles are separated from westbound trams (such as that involved in the accident) and westbound trams use a separate area of the road from which other road vehicles are prohibited (figure 3).

86 The refuge is located between the westbound road vehicle lane and the westbound tram lane. A crossing user, traversing Droylsden Road from south to north (as was the cyclist involved in the accident) is faced with the following:

- westbound road vehicles
- the pedestrian refuge
- westbound trams
- eastbound trams and eastbound road vehicles.

87 Therefore, unless a crossing user waits for the ‘green walking man’ indication (paragraph 9), the user must look in both directions to assure themselves that it is safe to continue crossing once they reach the pedestrian refuge. Markings painted onto the road surface (figure 15) remind the user to do so. This is in contrast to a user crossing from a pedestrian refuge of more conventional layout, where they are confronted by road traffic moving in only one direction.

88 It is probable that the cyclist was focused on the group of eastbound road vehicles. Therefore, it is likely that he made his decision to step from the refuge into the road unaware that a tram was approaching from the opposite direction.

The actions of the cyclist

89 The cyclist did not await the Puffin crossing indication that the road was safe to cross.

90 CCTV footage (paragraph 29) shows that the cyclist rode around the road-side of the pavement edge fencing at the south-west corner of the crossing and then to the mid-carriageway pedestrian refuge. The traffic signals controlling traffic on Droylsden Road were green when he did this, and traffic was flowing in both directions. The cyclist did not approach or interact with the Puffin crossing demand buttons on the south side of the crossing.

Figure 15: 'Look Both Ways' markings painted onto the road surface

91 At the point of the collision, traffic was moving normally along Droylsden Road in both directions, and CCTV footage shows the traffic lights showing a green aspect for these movements. This indicates that the cyclist did not wait until the Puffin crossing provided a 'green walking man' indication, showing that it was safe to move from the pedestrian refuge into the roadway. The pedestrian 'green walking man' phase did not operate in the immediate aftermath of the accident. Based on the available evidence, it is therefore likely that the cyclist did not operate the demand buttons which are located on the pedestrian refuge during the six seconds while he waited there (paragraph 30). The operation of the traffic lights and the crossing timings are discussed at paragraph 42.

92 It is not illegal for crossing users to cross without waiting for the 'green walking man' indication although Highway Code rule 23 provides guidance that users should wait for it to appear before crossing.

93 The cyclist did not dismount from his bicycle before using the crossing. Again, this is contrary to guidance provided by Highway Code rule 81 which states '*Do not ride across a pelican, puffin or zebra crossing. Dismount and wheel your cycle across*.' It cannot be determined whether the cyclist being mounted on his bicycle had any effect on the accident or its outcome.

Identification of underlying factor

The design risk identification and assessment process

94 The risk assessment processes used during the tramway design and construction phases did not identify the hazard to pedestrians created by the crossing layout until the tramway construction was advanced to a point where the design could not be easily changed.

95 Although a considerable amount of hazard identification and risk assessment work was carried out during the design phase for the East Manchester Line, this work did not identify the hazard which the unusual layout of the Kershaw Lane crossing presented to pedestrians. A road safety review carried out in February 2012 (see paragraph 131) was the first documented recognition of the hazard. However, by this stage, construction was advanced, and the design could not be easily amended (paragraph 70). Appendix C provides a chronology of the development of the East Manchester Line and documents referenced in this report.

Reviews by MPT and GMPTE

96 During 2010 and 2011, MPT carried out a number of design reviews and hazard identification sessions. None of these sessions identified the specific risk which the unusual crossing layout at the Kershaw Lane junction created.

97 During this period, GMPTE also carried out their own reviews of the project and the evolving designs being prepared by MPT. This included oversight by GMPTE's Safety Review Committee (see paragraph 156). Again, RAIB has identified no evidence that these sessions identified the specific risk at the Kershaw Lane junction.

98 On 17 December 2010, MPT issued a document[15] titled 'Designers Hazard Evaluation and Risk Reduction Form' which summarised their assessments of the hazards associated with the construction and operation of the Ashton section[16] of the East Manchester Line. Hazard reference D60 in this document identifies a situation where '*Pedestrian confusion as to which direction to look when crossing tramway at side of highway*' may lead to '*Pedestrian struck by tram or road vehicle when looking wrong way*'. This is evaluated as high risk. The document states that this *'Hazard cannot be completely eliminated'*, with mitigations including contrasting surface and signage.

99 The phrase '*at side of highway'* could indicate that hazard D60 was intended to cover situations where the tramway ran alongside an existing road (such locations existing nearer to Ashton-under-Lyne) rather than locations where the tramway was integrated with an existing road (such as the accident location). RAIB has found no evidence that there was recognition that the layout of the crossing at the Kershaw Lane junction was identified as presenting a similar high risk of pedestrians looking in the wrong direction.

[15] Document reference MPT3B-EMO-00-JRP-600.

[16] The 'Ashton section' refers to the section of the East Manchester Line between Droylsden tram stop and the terminus at Ashton-under-Lyne, which includes the location of the accident.

100 Although a number of options (paragraphs 64 to 67) were considered for the layout of the crossing at Kershaw Lane, RAIB has found no evidence that specific safety risks from the unusual, finally adopted, layout was considered within the applied decision-making process. Specifically, there was no documented analysis of the safety risks and benefits of the mid-carriageway pedestrian refuge. RAIB has been unable to establish why these reviews did not identify the risk posed by the crossing layout.

The compliance of the pedestrian refuge with published guidance – RSP2

101 Railway Safety Publication 2 (RSP2) was a document published by ORR which provided '*guidance and advice for those involved in the design and construction of...tramways'*. RSP2 was current at the time of the East Manchester Line project. It has since been superseded by LRSSB documents. RSP2 provided guidance to designers on tramways, and this included guidance on pedestrian crossings.

102 RSP2 did not include any specific guidance on the layout or positioning of mid-carriageway refuges (such as that found at the accident location).

103 In December 2012, the designers carried out a clause-by-clause commentary against RSP2. This review covered the entirety of the Ashton section of the East Manchester Line, including (but not specific to) the location of the accident. This commentary reported that the Ashton section, including sections covering pedestrian crossings, was compliant with RSP2.

The compliance of the pedestrian refuge with published guidance – LTN 2/95

104 Local Transport Note 2/95 (paragraph 44) provides guidance to designers regarding the layout of pedestrian crossings. Clauses 5.2.2 and 5.2.3 of this document state:

> *5.2.2 The use of a refuge at a non-staggered crossing is not recommended. They can be confusing for pedestrians and drivers and there is often insufficient space, particularly for prams and push chairs. They should, therefore, only be used if the road width cannot be increased locally to accommodate a staggered crossing. If used the refuge should be provided with push button(s) and signals as required.*
>
> *5.2.3 Where the road is more than 15 metres wide a staggered layout should be provided. If the road width is greater than 11 metres a staggered layout should be considered.*

105 The width of Droylsden Road at the accident location is 14 metres when measured from kerb to kerb so a staggered layout[17] should have been considered. RAIB has found no evidence that a staggered layout was ever considered. However, such a layout may have increased risk at the location because the stagger, when combined with a refuge in the 'as built' location, could have 'turned' pedestrians away from one of the prevailing directions of traffic.

[17] A staggered crossing layout is typically provided where a refuge exists between two opposing traffic directions. The objective of the layout is to encourage crossing users to face the direction from which the traffic is approaching.

106 Although it was not practicable to increase the road width, clause 5.2.2 of LTN 2/95 could have guided the designers towards consideration of a layout with no refuge. The outline design (paragraph 63) did not include a refuge, but the final design (paragraph 66) did include a refuge. RAIB has identified no evidence that the LTN 2/95 guidance led to a risk-based evaluation of the creation and placement of the refuge.

Consideration of alternative layouts – the September 2011 proposal

107 In September 2011, MPT (at TfGM request) prepared an alternative layout for the tramway which placed the pedestrian refuge between the tram tracks (paragraph 68).

108 MPT advised RAIB that this design was presented to TfGM, UTC, and Tameside MBC. MPT stated that these stakeholders rejected the design because:

- the arrangement did not have the capacity to cater for anticipated traffic flows leading to other safety risks/hazards
- the length of reserved tramway[18] through the junction was reduced
- providing a 'shared' queuing lane for the right-hand turn inbound into Kershaw Lane removed the benefit of a dedicated tram lane passing through the junction and would produce an uncontrolled tram-highway user interface and increased journey times.

109 Stakeholders also expressed concerns regarding available road space, including access by delivery vehicles to the convenience store.

110 The consideration of the September 2011 proposal did not recognise that the adoption of the alternative layout would have eliminated a safety issue (by the repositioning of the pedestrian refuge). On the basis of the evidence that is available, RAIB concluded that, by September 2011, the safety risk to pedestrians presented by the layout had not been recognised.

Opportunity to change the layout when Trambahn was changed to a FRTL layout

111 The change from Trambahn to FRTL in December 2011 (paragraph 69) removed the need to create the unusual layout at the Kershaw Lane junction; a more conventional layout with the tram tracks either side of right turn lanes (paragraph 58) could have been substituted.

112 However, construction of the tramway (paragraph 70) had advanced to a point where the track foundations were complete. As a result, the letter sent by TfGM to MPT instructing it to enact the change to FRTL included a general direction that the '*inbound*[19] *track was to be maintained in its current horizontal alignment*'.

113 RAIB has found no evidence to indicate that any consideration was given, at the time of the decision to change from Trambahn to FRTL, to any opportunity to re-visit the track layout at the Kershaw Lane junction.

[18] That is, Trambahn; in September 2011, the decision to change from Trambahn to FRTL had not been taken.

[19] 'Inbound' refers to trams travelling towards Manchester city centre; the term 'Westbound' is used elsewhere in this report.

The Highways Reference Group

114 MPT recognised that there were a considerable number of organisations who were involved with, and needed to comment upon, the detailed design of the East Manchester Line. With this in mind, a 'Highways Reference Group' (HRG) was established. The first HRG meeting took place on 30 April 2010. The participants in the HRG meetings were representatives from MPT, GMPTE, UTC and Tameside MBC. Each HRG meeting scrutinised in detail specific aspects of the design of the East Manchester Line.

115 The sixth HRG meeting, on 21 July 2010, included (as an appendix to the meeting) a 'Design agreement in-principle' which was signed (on the date of the meeting) by the representative of Tameside MBC. The meeting notes included references to concerns regarding access by goods vehicles serving the convenience store. However, none of the HRG meetings identify the potential risks to pedestrians posed by the unusual layout.

116 It is not certain which version of the design drawings was presented to the meeting on 21 July 2010. However, given that the design had evolved by June 2010 (paragraph 66) to include the pedestrian refuge, RAIB considers it likely that the design agreed during the sixth HRG meeting in July 2010 depicted the refuge in its final position.

117 The final HRG meeting took place on 19 November 2010. The HRG was not formally re-convened to consider the implications of the change from Trambahn layout to FRTL which took place in 2011 (paragraph 69). However, the HRG stakeholders were aware of the later change as a result of their co-operation on the project.

Road Safety Audits

118 During the deliberations of both MPT and the HRG meetings, considerable emphasis was placed by all participants on the Road Safety Audit (RSA) as a means of identifying hazards and mitigating the risks identified during the project.

119 The requirements for RSAs are documented in the UK's 'Design Manual for Roads and Bridges'[20] (DMRB). At the time of the East Manchester Line design and construction, DMRB section 5 volume 2 document HD 19/03 'Road Safety Audit' provided detail on the process and methodology for carrying out such audits. This document was overseen by the Highways Agency,[21] an executive agency of the Department for Transport. The introduction to document HD 19/03[22] states that '*The objective of Road Safety Audit is to identify any aspects of a Highway Improvement Scheme that give rise to road safety concerns and, where possible, to suggest modifications that would improve the road safety of the resultant scheme'.*

120 HD 19/03 places the responsibility for road safety audits on an 'Overseeing Organisation', and defines that organisation as '*The highway authority responsible for the Highway Improvement Scheme to be audited*.'

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[20] See https://www.standardsforhighways.co.uk/dmrb/.

[21] The Highways Agency was replaced by Highways England on 1 April 2015, and then by National Highways during 2021.

[22] Document HD 19/03 was subsequently superseded by HD 19/15 effective from 31 March 2015, and then by document GG119; the current version of GG119 (version 2) became effective from January 2020.

121 National Highways advised RAIB that '*GG119 isn't mandated for use on the local highway authority (LHA) network but may be adopted, either in whole or in part, at the discretion of an individual LHA. It appears … that the location in question forms part of the LHA network. The Overseeing Organisation is usually the organisation promoting the highways scheme to be audited.'* Both Droylsden Road and Kershaw Lane are managed by Tameside MBC as LHA roads.

122 HD 19/03 and its successor documents identify four stages of the RSA process. These are:

- stage 1 – at completion of preliminary design
- stage 2 – at completion of detailed design
- stage 3 – at completion of construction
- stage 4 - post opening monitoring.

123 Within the contract between GMPTE and MPT, there was an explicit requirement for MPT to deliver stages 1 to 3 of the RSA process. There was no such requirement covering stage 4.

124 The stage 1 RSA was carried out in September 2010; an addendum stage 1 RSA was carried out in December 2011 in response to the design change which replaced Trambahn with the FRTL (paragraph 69, appendix C). The stage 2 RSA was carried out in January 2011. As with stage 1, an addendum Stage 2 RSA was carried out in June 2012 in response to the change from Trambahn to FRTL.

125 Neither the stage 1 nor stage 2 audits recognised the risk to pedestrians posed by the unusual layout at the Droylsden Road/Kershaw Lane junction. This meant that any possible opportunities to review and, if possible, to amend the design to remove the problem were not taken.

126 During June 2013, MPT carried out the stage 3 RSA. By this time, construction of the tramway was complete and trams were running as far as Droylsden tram stop. This audit identified a hazard, reference CC3, summarised as:

'*The layout and position of the crossing point could result in user confusion, which increases the risk of collisions with passing vehicles/trams*'.

In more detail, the audit identified that:

'*Given the provision of the refuge island, many pedestrians may assume that all vehicles passing to the north of the island will be going east-bound and vice-versa. However, trams travelling along the dedicated tram lane will be going westbound to the north of the island, which may seem counterintuitive to many people using the crossing*.'

This description of the hazard captures the probable circumstances of the accident of 1 September 2021. It also aligned with the findings of the road safety review, which had been conducted in 2012 (see paragraph 131).

127 In response to hazard CC3, the stage 3 audit team recommended that:

> '*'LOOK BOTH WAYS' markings should be laid at both of the crossing points on the north side of the central refuge island. It would also be beneficial to add 'LOOK RIGHT' and 'LOOK LEFT' markings to the south of the island.'*

The 'look both ways' markings were laid as recommended, and were found to be in place on the day of the accident (figure 15). However, the recommended markings to the south of the island were not in place. RAIB has been advised that these markings were never laid.

128 RAIB has found no evidence that the stage 4 RSA was carried out. Neither Tameside MBC nor TfGM made any arrangements for the stage 4 RSA, and neither organisation was aware that the stage 4 RSA had not been carried out. The stage 4 RSA, had it been completed, may have identified accidents which occurred at the location following completion of the project (see paragraph 166). However, given that the stage 3 RSA fully identified the hazard, RAIB considers it unlikely that the omission of the stage 4 audit would have led to further changes which may have prevented the accident.

129 RAIB noted that there is no mention of trams, tramways or light rail schemes in document HD 19/03 nor any of the later documents, including GG119. In the context of major projects involving multiple organisations (such as the East Manchester Line), it is unclear which entity fulfils the role of the 'overseeing organisation' (paragraph 120) with responsibility for ensuring that RSAs are carried out.

130 RAIB discussed with LRSSB the applicability of the RSA concept to tramway projects such as the East Manchester Line. LRSSB reported that the reliance on the RSA as a primary means to manage risk had been problematic on other similar schemes elsewhere in the UK. LRSSB also stated that some schemes had developed alternative methodologies for the management of risks which could be regarded as being within the scope of the RSA process.

Road Safety Review of Kershaw Lane junction

131 In early 2012, TfGM commissioned WS Atkins to undertake a road safety review of the Kershaw Lane junction in the light of the change from Trambahn to FRTL. The report summarising the outcome of the review, dated February 2012, addressed a number of specific queries, one of which was '*Pedestrians crossing Droylsden Road on the eastern side of Kershaw Lane heading north would not be prepared for trams approaching from the east*.'

132 Although the query is specific to the eastern side of the junction, this is the first document identified by RAIB which anticipates the circumstances of the accident of 1 September 2021. It is possible that the query did not specifically include the western side of the junction because of the provision of the Puffin crossing at that side of the junction.

133 The review noted that:

> *'A signal controlled route is provided across both Kershaw Lane side roads and the western side of the junction. It is, therefore, a low likelihood that anyone will attempt to cross on the eastern side. If pedestrians did attempt to cross, there is a small traffic island or the hatched ghost island that could be used by a pedestrian as a refuge and to split the crossing into two steps. From this position approaching trams from either direction should be clearly visible. Suggested improvements include:*
>
> a. *Using 'Look both ways' road markings (similar to diagram number 1029) on both of the northern sides of the western pedestrian crossing*
>
> b. *'Tramway Look both ways' pedestrian signs (diagram number 963.3) attached to the signal poles on the northern sides of the western crossing*.'

The improvements suggested in the review all apply to the western side of the crossing. This suggests that the review had identified that the same risk was present at the crossing on the western side of the junction. The road markings were also noted by the stage 3 RSA (paragraph 126) and were implemented at the accident location. However, diagram 963.3 signage was not provided.

134 The road safety review considered the relative safety of Trambahn against FRTL and concluded that the FRTL '*should be at least as safe in operation'* as the Trambahn. No apparent consideration was given to a revision of the layout in response to the change from Trambahn to FRTL, and the opportunity which this potentially offered to remove the identified hazard at this location. However, by the date of the report (February 2012), construction had reached a point where such a layout change was not readily achievable; because of this, TfGM had instructed MPT to retain the horizontal alignment of the westbound tramway (paragraph 112).

135 TfGM commissioned the road safety review, and the queries which the review addressed had originated from TfGM. This therefore suggests that there was awareness of the potential hazards of the layout at the Kershaw Lane junction in early 2012. However, RAIB has been unable to identify any record of such awareness (and therefore any mitigation actions) being recorded in the formalised risk management processes within the TfGM Safety Management System (see paragraph 154).

The provision of diagram 963.3 signage

136 RSP2 (paragraph 101) required that signage for other road users consequent on the introduction of a tramway was to be provided in accordance with the Traffic Signs Regulations and General Directions (TSRGD). These regulations '*prescribe the designs and conditions of use for traffic signs, including road markings, traffic signals and pedestrian, cycle and equestrian crossings used on or near roads*.'[23] The requirements of TSRGD are legally binding and are supported by the 'Traffic Signs Manual'[24] (TSM).

[23] See https://www.gov.uk/government/publications/traffic-signs-regulations-and-general-directions-2016-an-overview. Although dated 2016, their provisions are not significantly changed from the provisions in force at the time of the construction of the East Manchester Line.

[24] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/782724/traffic-signs-manual-chapter-03.pdf.

137 Section 10.3 of Chapter 3 of the TSM documents the ‘Diagram 963.3’ signage (figure 16). Neither TSRGD nor the TSM mandate the use of these signs at locations such as the site of the accident; they equally do not prohibit the use of such signage.

Figure 16: Diagram 963.3 signage in place elsewhere on the Metrolink network

138 LRSSB advised RAIB that the use of such signs at a crossing on a tramway which is integrated with the road would be unusual; these signs are more commonly found to warn pedestrians of a tramway crossing where the tramway is segregated from a road. Tameside MBC advised RAIB that they would not have objected to the provision of such signage, but that they have a general duty to reduce the level of ‘sign clutter’ on roads. TfGM advised RAIB that diagram 963.3 signs are generally not used on sections of the Metrolink network where trams share road space with other users (as at the location of the accident).

139 In addition to the road safety review (paragraph 131), RAIB identified several documents generated by MPT which included the provision of these signs as a means of mitigating the risk to pedestrians on the East Manchester Line. None of these documents specifically covered the crossing at Kershaw Lane. The documents were:

- The December 2012 commentary against RSP2 (paragraph 103). Item 53 in this commentary, under the heading 'On-street tramway intersections with other roads' stated '*signs giving warning of the presence of trams should be provided and details of these are in the Traffic Signs Regulations and General Directions 2002*.'
- An August 2013 document[25] 'Designer's Risk Assessment for pedestrian crossings' specified '*Warning signs advising public to look out for trams in both directions*' as a control measure in the section described as 'Generic Track Crossing Hazards'.

140 No diagram 963.3 signs were provided at the accident location. It cannot be determined what effect, if any, these signs would have had on the behaviour of crossing users and specifically on the actions of the cyclist involved in the accident.

The June 2013 risk and difference meeting and associated workshops

141 In the case of the East Manchester Line beyond Droylsden, RAIB has identified no evidence indicating a documented application of the ROGS risk and difference test (paragraph 72) until a meeting which took place on 17 June 2013. This meeting was attended by representatives of TfGM and MRDL. The meeting concluded that Safety Verification for the project was not required. This decision therefore meant that the project, and the risks associated with it, was to be managed in accordance with the safety management systems of both TfGM and MRDL. However, the meeting identified concerns with the layout at the Droylsden Road/Kershaw Lane junction. The outcome of these concerns is discussed at paragraph 145.

142 Because the risk and difference meeting concluded that Safety Verification for the project was not required, no ICP (paragraph 73) was required for the project, and none was appointed. An individual who had, in the past, acted as ICP on tramway projects was retained as an advisor for the project. However, this individual had no recollection of having dealt with the layout at the accident location as part of his advisory work.

143 In addition to determining that Safety Verification was not required in respect of the East Manchester Line, the 17 June 2013 risk and difference meeting identified issues regarding the unusual layout at the Droylsden Road/Kershaw Lane junction. The meeting noted that '*The main risk was identified as pedestrians crossing on the eastern side of the junction in line with the shopping parade against a red man using the traffic island / central hatching'.* The meeting instructed that a separate workshop was to be held to consider risks at this location.

[25] Document reference MPT3B-EMD-00-KRP-600.

144 This workshop took place on 2 July 2013, and included representatives from TfGM, MPT, Tameside MBC and MRDL. The meeting notes record that '*All agreed that the hazard with greatest risk involved pedestrians crossing Droylsden Road against a red man on the eastern arm of the junction using the hatching, and being unaware of an approaching inbound tram*.'

145 Although the exact intent of this statement is now unclear, since the Puffin crossing (and hence the 'red standing man') is located on the western arm of the junction,[26] the meeting recommended a number of mitigations for the location, which included:

- installing 'Tramway Look Both Ways' road markings on the northern side of the pedestrian crossing (one at the traffic island and a second at the edge of carriageway)
- changing the hatching to chevron markings on the eastern side of the junction
- extending the red tram lane surfacing across the rail shoulders
- lengthening the red tram lane surfacing into the Kershaw Lane junction from both side
- inserting arrows in the tram lane adjacent to each 'TRAM ONLY' markings in the directional of travel (similar to contra-flow bus lanes)
- inserting repeater 'TRAM ONLY' markings and directional arrows at regular intervals along the Reserved Tram Lane.

All of these measures were implemented and were in place at the time of the accident (figure 16). The meeting minutes do not record any consideration of 'diagram 963.3' signs (paragraph 136).

146 Although the risk and difference meeting and associated workshops correctly identified the risk which the layout at the Kershaw Lane junction posed, the design and construction phase of the project had been completed many months earlier. The meeting did not evaluate if any fundamental changes to the layout were practicable. The minutes of the July 2013 workshop included a statement that '*the group agreed that the above recommendations formed the sum extent of reasonable and practicable recommendations that could be incorporated at the Kershaw Lane Junction*'.

147 Had the risk and difference meeting occurred earlier in the project, it is possible that the meeting would have identified the risk before construction started.

MRDL operational risk assessment GS-EXP-AUL001

148 The June 2013 meeting also required that MRDL carried out an operational risk assessment. MRDL reported at the July 2013 workshop that the speed limit for westbound trams had been reduced to 20 mph (32.2 km/h); the speed limit for eastbound trams would remain at 30 mph (48.2 km/h), the prevailing speed limit for other road users on Droylsden Road.

[26] There were a number of other issues with the minutes of the meeting; it is most likely that the confusion between the eastern and western legs of the junction was an error made when documenting the meeting.

149 The outcome of the June 2013 risk and difference meeting (paragraph 141) meant that MRDL's safety management system (along with that of TfGM) was the primary means of project risk management. In September 2013, MRDL completed the operational risk assessment required by their safety management system. This risk assessment, identified as GS EXP-AUL001, covered the 'Operation of EML extension from Droylsden to Audenshaw in passenger service'. The individuals who undertook this work had also attended the June 2013 risk and difference meeting and the subsequent workshops covering the Kershaw Lane junction. They were therefore familiar with the location and the hazards which the unusual crossing layout presented.

150 GS EXP-AUL001 included a specific hazard described as '*tram strikes pedestrian travelling inbound at Kershaw Lane due to unusual road layout*'. Stated mitigations included driver training and the reduced speed limit (20 mph (32.2 km/h)) for westbound trams discussed in the July 2013 workshop. Former MRDL staff who compiled GS EXP-AUL001 advised RAIB that the choice of a 20 mph (32.2 km/h) limit for westbound trams was a balance between reducing the stopping distance for a tram in an emergency against the risk of other road vehicles (permitted to travel at up to 30 mph (48.2 km/h)) colliding with a tram moving at a lower speed.

151 The requirements of GS EXP-AUL001 were reflected in the training provided to drivers on the East Manchester Line, including the driver of the tram involved in the accident, who were specifically warned of the hazard at the location, including the lower speed limit.

152 MRDL (and later KAM) made extensive use of simulators to provide drivers with experience of handling unexpected situations. One such simulator scenario covered a pedestrian crossing at the Kershaw Lane junction, albeit on the eastern side of the junction rather than the western side (the accident location). The tram driver involved in the accident recalled being trained on this simulator scenario.

Non-motorised users assessment

153 In October 2020, KAM commissioned a review of all crossings on the Metrolink system, including the Kershaw Lane/Droylsden Road crossing. The review noted that the positioning of the traffic refuges at this location was unusual, and that a previous accident with a pedestrian had occurred in 2014 (see paragraph 167). As the review was carried out by a person who had attended the 2013 risk and difference meeting (paragraph 141), the 2020 review reported the various mitigations which had been put in place following the risk and difference meeting and the associated workshops. The 2020 assessments did not recommend any change or further mitigations at the western side of the junction (where the accident took place) but did recommend additional signage at the eastern side of the junction. This additional signage was intended to warn pedestrians of the two-way flow of trams ahead. The recommended additional signage at the eastern side of the junction had not been installed at the time of the accident.

Oversight of the East Manchester Line project by GMPTE/TfGM

154 Throughout the project, GMPTE/TfGM used a hazard log as their primary means of project safety risk control. This was used to record hazards as they were identified, to assess the risk posed by these hazards, and then record how these risks were mitigated.

155 The hazard log had no entries relating to the unusual layout at the Droylsden Road/Kershaw Lane junction until the 17 June 2013 risk and difference meeting (paragraph 141) had identified the hazards. This indicates a lack of awareness within GMPTE/TfGM of the hazard until this date, despite the road safety review carried out on behalf of TfGM in 2012, which identified the problem (paragraph 131).

156 Senior management safety oversight of projects such as the East Manchester Line was by means of a Safety Review Committee (SRC). The SRC reviewed major projects on the Metrolink system to ensure that all safety issues were managed appropriately. The SRC meeting of 1 October 2013 authorised the opening of the East Manchester Line between Droylsden and Ashton-under-Lyne to public traffic. No specific mention of the Kershaw Lane junction has been found in any SRC meeting minutes.

Observations

Other risk assessment work carried out by the tram operator

157 Risk assessments carried out by the Metrolink system operator were incomplete, unavailable or had not been reviewed following earlier accidents or on a periodic basis.

158 As the operator of the East Manchester Line until July 2017, MRDL was required by the relevant law, including ROGS, to assess and control the risks connected to its operation of the tramway. Risk assessments of the project were also identified as a requirement during the June 2013 risk and difference meeting (paragraph 141) and the associated workshops. After taking over as the tramway operator in July 2017, KAM became responsible for the assessment and control of risk.

159 RAIB reviewed the available operational risk assessments. A number of shortcomings were identified, and these are described in paragraphs 160 to 168. However, RAIB concluded that these shortcomings did not contribute to the accident. MRDL and (later) KAM, as the operator of the tramway, were limited in terms of the scope of actions which could be taken. It is unlikely that addressing the identified shortcomings in the operational risk assessments would have led to additional measures which could have prevented the accident.

Risk assessment NMC0041

160 Risk assessment NMC0041 '*Operating trams across the simple road junction at Kershaw Lane/ Ashton New Road, inbound direction'* was completed by MRDL before the East Manchester Line opened beyond Droylsden (on 9 October). This document identified a hazard of 'Pedestrian ignores traffic signals and steps into path of tram'. Stated mitigations included:

- *UTC signals control the junction*
- *road markings and signage on approach to the junction*
- *trams subject to appropriate speed limits across the junction*
- *drivers subject to Metrolink rulebook and associated procedures*

- *drivers trained and assessed on a regular basis*
- *drivers trained and operate defensive driving techniques*.

161 RAIB compared the contents of NMC0041 to similar risk assessments conducted at the same time, and which covered other road junctions on the East Manchester Line. This comparison showed that the above hazard, and its mitigations, were the same at each road crossing. No mention was made of the unusual hazards at the accident location, despite the existence of the earlier location-specific risk workshop (paragraph 144).

162 NMC0041 stated that it was due for review on 8 January 2014. No evidence has been located indicating that this review was ever carried out by either MRDL or KAM.

Risk assessment GS EXP-AUL001

163 During the investigation, it became apparent that KAM no longer had access to GS EXP-AUL001 (paragraph 148), the document having been misplaced during the transition of operators from MRDL to KAM. Therefore, although the 20 mph (32.2 km/h) limit remains in place, and drivers are trained on the specific hazards at the Kershaw Lane junction, KAM lacked an understanding of why these measures were put in place.

Risk assessment SD002

164 In April 2019, KAM undertook a further risk assessment of the East Manchester Line in connection with a problem with the tram control system which is unrelated to this accident. This assessment, reference SD002, extensively referenced NMC0041. SD002 was carried out, in part, by assessing the tramway between each stop. However, the section between Droylsden and Audenshaw, past the accident location, was omitted from this exercise. KAM advised RAIB that this was most likely due to an oversight.

165 The omission of the Droylsden-Audenshaw section from SD002 was a missed opportunity to recognise that NMC0041 was significantly overdue revision (paragraph 162) or that GS EXP-AUL001 was no longer available to KAM (paragraph 163).

Review of risk assessments following incidents and accidents

166 KAM identified to RAIB that there had been three reported previous incidents at or close to the accident location. All three were minor road traffic accidents with cars, and therefore not directly comparable with the accident on 1 September 2021.

167 Tameside MBC also collates accident data, and it advised RAIB of a pedestrian accident in June 2014. Details of this accident are sparse, but it was recorded that the pedestrian was crossing from south to north at the junction. It is not known if they were crossing on the eastern or the western side of the junction. KAM did not have ready access to the records of this accident, but was able to retrieve the data from an archived system.

168 It is good practice that risk assessments are reviewed when incidents or accidents are reported. There is no evidence that any of these previous events had triggered such a review.

Serviceability of equipment on M5000 trams

169 The tram involved in the accident was found to have three defective sanders and an inoperative on-board CCTV system.

Defective Sanders

170 Post-accident checking by KAM identified that three of the four sanders which would operate in this direction of travel were defective. KAM advised RAIB that the tram sanding system had been previously examined as part of a planned maintenance activity in July 2021 and was found to be operational at that time.

171 Wheel slide occurs when the forces being applied by the tram's braking system exceed those which can be transferred through the wheel-rail interface. These sanders act to locally increase the coefficient of friction between the vehicle wheel (and track brakes) and the rail, and hence the retarding forces which can be transferred.

172 OTDR data indicated that the tram experienced wheel slide[27] after the hazard brake had been deployed. This is the most likely reason for the tram braking at a rate slightly below that expected (paragraph 40). This reduced braking rate may possibly have been avoided if all of the tram's sanders had functioned correctly.

Defective CCTV system

173 Examination of the tram after the accident showed that the CCTV system on the tram involved in the accident had ceased to record at 07:03 hrs on 28 August. The system started to work again at 23:29 hrs on the day of the accident; this was probably because the tram's systems were reset during the post-accident recovery of the tramway.

174 A functional CCTV system, including the forward-facing camera, would likely have provided imagery which would have been of considerable value to any investigation.

Previous occurrences of a similar character

175 RAIB has previously reported on accidents in which tram CCTV systems were non-operative. Examples of this include RAIB report 18/2017 'Overturning of a tram at Sandilands junction, Croydon' and RAIB report 15/2019 'Passenger injury at Ashton-under-Lyne tram stop'.

176 RAIB report 06/2020 covered a signal passed at stop and near miss at the Deansgate-Castlefield tram stop on the Metrolink system during May 2019. Paragraph 95 of this report covered the recognition and control of risk by parties involved in the development of this location on the Metrolink system.

[27] The OTDR system records this data from the unpowered centre bogie. It cannot be determined definitively if the other two bogies suffered wheel slide at the same moment due to the absence of recorded data.

Summary of conclusions

Immediate cause

177 The cyclist moved into the road immediately in front of the approaching tram (paragraph 77).

Causal factors

178 The causal factors were:

a. The cyclist's attention was probably focused on eastbound road traffic so he may have been unaware of the tram's approach from the opposite direction (paragraph 81, **Recommendation 1**).

b. The cyclist did not await the Puffin crossing indication that the road was safe to cross (paragraph 89, no recommendation).

Underlying factors

179 The risk assessment processes used during the tramway design and construction phases did not identify the hazard to pedestrians created by the crossing layout until the tramway construction was advanced to a point where the design could not be easily changed (paragraph 94, **Recommendations 2 and 3**).

Additional observations

180 Although not directly linked to the cause of the accident on 1 September 2021, RAIB observes that:

a. Risk assessments carried out by the Metrolink system operator were incomplete, unavailable or had not been reviewed following earlier accidents or on a periodic basis. (paragraph 157, **Recommendation 4**, **Learning point 1**).

b. The tram involved in the accident was found to have three defective sanders and an inoperative on-board CCTV system (paragraph 169, **Recommendation 5**).

Previous RAIB recommendations relevant to this investigation

181 The following recommendations, which were made by RAIB as a result of its previous investigations, have relevance to this investigation.

Overturning of a tram at Sandilands junction on 9 November 2016, RAIB report 18/2017

182 Following this accident on the Croydon tram system, RAIB made two recommendations which are relevant to the accident on 1 September 2021.

183 Recommendation 2 of this report read as follows:

> *The intent of the recommendation is to better understand all safety risk associated with tramway operation and then provide updated guidance for the design and operation of tramways (this could be achieved by issuing an updated version of the 'Guidance on tramways' with expanded coverage of operational matters). Particular attention will be required to recognise risks from low frequency / high consequence events which may not be apparent from precursor incidents on existing UK tramways. Identifying such events is likely to require input from specialists outside the UK tram community, including specialists with knowledge of main line rail and bus environments. Consideration of main line rail and bus issues is intended to inform evaluation of tramway risks; it does not imply that all heavy rail and bus requirements should be applied to tramways.*
>
> *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 (paragraphs 467 and 468).*

184 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 LRSSB.

185 The current status of recommendation 2 is 'on-going'.

186 Recommendation 14 of this report read as follows:

> *The intent of this recommendation is to maximise the availability of CCTV images which could assist accident and incident investigation (and also the investigation of criminal acts and anti-social behaviour). It considers both technical reliability and processes used to recover images before they are over-written. It is probable that equipment installed since November 2016 on trams similar to that involved in the accident will assist implementation of this recommendation.*
>
> *London Trams, in consultation with Tram Operations Limited, should review and, where necessary, improve its processes for inspecting and maintaining on-tram CCTV equipment to greatly reduce the likelihood of recorded images being unavailable for accident and incident investigation (paragraph 471).*
>
> *This recommendation may apply to other UK tram operators.*

187 The current status of recommendation 14 is 'implemented'. This recommendation was not made specifically to TfGM or KAM, and no specific action has been reported in response to this recommendation by those organisations.

Recommendations and learning point

Recommendations

188 The following recommendations are made:[28]

1 *The intent of this recommendation is that safety at the crossing involved in the accident is improved.*

Transport for Greater Manchester and Tameside Metropolitan Borough Council, working as necessary with Keolis Amey Metrolink, should undertake a revised risk assessment of the crossing where the accident occurred. This assessment should be conducted in line with current industry good practice and should specifically consider both the circumstances in which this accident occurred and the nature of the crossing layout.

Transport for Greater Manchester and Tameside Metropolitan Borough Council should identify measures which will reduce the risk to users of the crossing so far as is reasonably practicable, based on the findings of this assessment. Any identified improvements should be implemented. As part of this process, Transport for Greater Manchester and Tameside Metropolitan Borough Council should consider what actions should be adopted to control the risks identified during the period in which any longer-term actions are being implemented.

2 *The intent of this recommendation is to ensure that risks are appropriately managed during future Metrolink development projects.*

Transport for Greater Manchester should review its safety management system to ensure that the systems and processes used to identify hazards and control risks:

a) are implemented at a point in project lifecycles which will allow risks to be addressed in a timely fashion, such that better mitigations can be achieved at proportionate cost

b) correctly apply the requirements of 'The Railways and Other Guided Transport Systems (Safety) Regulations 2006', including those relating to Safety Verification and the application of the risk and difference test at an appropriate point within a project

[28] 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.

c) include processes to ensure that risk assessments produced by suppliers meet the requirements of the safety management system and that the results of assessments prepared by other relevant third parties are accounted for.

3 *The intent of this recommendation is that guidance is produced to clarify the role of the road safety audit process to tramway projects.*

LRSSB should review the application of road safety audits as a means to identify and mitigate hazards during tramway development and construction projects. This review should identify areas where the road safety audit process may be beneficial or where its use may lead to hazards not being appropriately identified or mitigated. This review should also identify and clarify responsibilities for delivering and managing the road safety audit process for tramways. LRSSB should engage with National Highways as required during this review process. The outcome of this review should be used where appropriate to produce revised guidance for the use of organisations involved in the development and construction of tramway schemes.

4 *The intent of this recommendation is to ensure that operational risk assessments for the Metrolink system are complete.*

Keolis Amey Metrolink should review the operational risk assessments covering the operation of trams across the Metrolink network for completeness and adequacy. This review should ensure that information from previous accidents and near misses is incorporated into current risk assessments and that the reason for any current operational restrictions on the system are fully understood and remain appropriate.

5 *The intent of this recommendation is to ensure that, as far as is reasonably practicable, systems on Metrolink trams are serviceable.*

TfGM (as asset owner) and KAM (as equipment maintainer) should review the reliability, operation and maintenance of sanding equipment and CCTV on M5000 trams to ensure that they are fit for purpose.

This review should identify appropriate improvements in the maintenance regime or the equipment design which will improve their reliability. These improvements should be applied both to the current fleet of M5000 trams and for any vehicles procured for the Metrolink network in the future.

Learning point

189 RAIB has identified the following important learning point:[29]

1 This accident shows the importance of ensuring that robust systems and processes are in place to ensure the continuity and transfer of corporate memory, including documentation and records, during organisational change, such as the transfer of operational contracts from one organisation to its successor.

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

Appendices

Appendix A - Glossary of abbreviations and acronyms

CCTV	Closed-closed circuit television
DMRB	Design Manual for Roads and Bridges
EML	East Manchester Line
FRTL	Flush Reserved Tram Lane
GMPTE	Greater Manchester Passenger Transport Executive
HRG	Highways Review Group
ICP	Independent Competent Person
KAM	Keolis Amey Metrolink
LHA	Local Highways Authority
LRSSB	Light Rail Safety and Standards Board
LTN	Local Transport Note
MBC	Metropolitan Borough Council
MRDL	Metrolink RATP Dev Ltd
MPT	M-Pact Thales
ORR	Office of Rail and Road
OTDR	On-Tram Data Recorder
RATP	Régie Autonome des Transports Parisiens
ROGS	The Railways and Other Guided Transport Systems (Safety) Regulations 2006
RSA	Road Safety Audit
SRC	Safety Review Committee
TfGM	Transport for Greater Manchester
TSM	Traffic Signs Manual
TSRGD	Traffic Signs Regulations and General Directions
UTC	Urban Traffic Control

Appendix B - Investigation details

RAIB used the following sources of evidence in this investigation:

- information provided by witnesses
- information taken from the On-Tram Data Recorder (OTDR)
- closed-circuit television (CCTV) recordings taken from Droylsden tram stop, the convenience store and from a tram which had departed from Droylsden tram stop at the time of the accident
- site photographs and measurements
- weather reports and observations at the site
- testing of the tram involved
- evidence provided by TfGM, Tameside MBC, MPT, KAM and former MRDL/KAM employees
- a review of previous RAIB investigations that had relevance to this accident.

Appendix C - Chronology of dates and activities referenced in this report

Date	Activity	Report reference
1994	Public consultation.	Paragraph 50, figure 7
August 1998	Making of The Greater Manchester (Light Rapid Transit System) 51 (Ashton-under-Lyne Extension) Order 1998.	Paragraph 57
January 2010	GMPTE-developed concept design. No refuges shown.	Paragraph 61, figure 10
March 2010	Contract signed between GMPTE and MPT for the construction of the East Manchester Line.	Paragraph 64
April 2010	MPT initial design. No refuge provided at western side of junction.	Paragraph 65, figure 11
April 2010	Initial meeting of Highways Reference Group (HRG).	Paragraph 114
June 2010	MPT evolves design. Refuge provided in ‘as built’ location at western side of junction.	Paragraph 66, figure 12
July 2010	MPT provides design commentary to GMPTE.	Paragraph 67
July 2010	HRG meeting no.6; Kershaw Lane junction design sign-off.	Paragraph 115
September 2010	Stage 1 Road Safety Audit carried out.	Paragraph 124
December 2010	MPT issues Designers Hazard Evaluation and Risk Reduction Form.	Paragraph 98
January 2011	Stage 2 Road Safety Audit carried out.	Paragraph 124
February 2011	Construction at road junction commences.	
April 2011	GMPTE becomes TfGM.	Paragraph 17
September 2011	MPT produces alternate design, with refuge between tram tracks.	Paragraph 68, figure 13, paragraph 107
December 2011	Decision taken to change from Trambahn to FRTL design.	Paragraph 69
December 2011	Addendum to Stage 1 Road Safety Audit carried out (to reflect change to FRTL design).	Paragraph 124

Date	Activity	Report reference
February 2012	Road Safety Review of Kershaw Lane junction.	Paragraph 131
June 2012	Addendum to Stage 2 Road Safety Audit carried out (to reflect change to FRTL design).	Paragraph 124
December 2012	MPT produces clause-by-clause commentary against Railway Safety Publication 2.	Paragraphs 103 and 139
February 2013	East Manchester Line opens from Manchester city centre to Droylsden.	Paragraph 70
June 2013	Stage 3 Road Safety Audit carried out.	Paragraph 126
June 2013	Risk and difference meeting.	Paragraph 141
July 2013	Workshop arising from risk and difference meeting.	Paragraph 144
August 2013	Designer's Risk Assessment for pedestrian crossings.	Paragraph 139
August 2013	Test operation commences from Droylsden to Ashton-under-Lyne.	
September 2013	MRDL produces risk assessment GS EXP-AUL001.	Paragraph 149
October 2013	TfGM Safety Review Committee meeting authorises opening of East Manchester Line from Droylsden to Ashton-under-Lyne.	Paragraph 156
October 2013	East Manchester Line opens from Droylsden to Ashton-under-Lyne, including the accident location.	Paragraph 70
July 2017	Metrolink operator changes from MRDL to KAM.	Paragraph 15

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