

Oliver Stewart
Senior Executive, RAIB Relationship and
Recommendation Handling

Telephone 020 7282 3864

E-mail oliver.stewart@orr.gsi.gov.uk

5 April 2019



Mr Andrew Hall
Deputy Chief Inspector of Rail Accidents
Cullen House
Berkshire Copse Rd
Aldershot
Hampshire GU11 2HP

Dear Andrew,

RAIB Report: Overturning of a tram at Sandilands junction, Croydon, 9 November 2016

I write to provide an update¹ on the action taken in respect of recommendations 3, 4, 5, 7 and 10 addressed to ORR in the above report, published on 7 December 2017.

The annex to this letter provides details of the action taken regarding the recommendations.

The status of recommendations 3, 5 and 10 is '**implemented**' for London Trams/Tram Operations Ltd.

Recommendation 4 is '**implementation on going**' for Edinburgh Trams and West Midlands Metro/Transport for West Midlands.

Recommendation 7 is '**implemented**' for Transport for Greater Manchester/Manchester Metrolink Ltd and '**implementation on going**' for London Trams/Tram Operations Ltd.

We will publish this response on the ORR website on 5 April 2019.

¹ In accordance with Regulation 12(2)(b) of the Railways (Accident Investigation and Reporting) Regulations 2005

Yours sincerely,

A handwritten signature in black ink, appearing to read 'Oliver Stewart', with a stylized, cursive script.

Oliver Stewart

Recommendation 3

The intent of this recommendation is to prevent serious accidents due to excessive speed at higher risk locations on tramways. These locations are likely to include all locations where a substantial speed reduction is required for trams approaching at relatively high speed. Implementation of this recommendation may be assisted by work in this area already underway by Croydon tramway organisations.

UK tram operators, owners and infrastructure managers should work together to review, develop, and provide a programme for installing suitable measures to automatically reduce tram speeds if they approach higher risk locations at speeds which could result in derailment or overturning

ORR decision

London Trams/Tram Operation Ltd

1. Since our initial response to the Sandilands report, London Trams have provided more detail about the programme to install a physical prevention of over-speeding system (PPOS).
2. LT and TOL identified a suitable system to support this recommendation and LT has awarded a contract to implement PPOS by the end of 2019, initially at high risk locations on the Croydon network. The system is designed to automatically apply the brakes and bring a tram to a stop should a clear over speed violation occur. TOL and LT are in the process of identifying and agreeing the high-risk locations where the system should be installed.
3. LT/TOL have stated they will review the output from the Ian Rowe Associates Ltd (IRAL) research for UKTram into overspeed detection and driver vigilance devices to determine if any further measures should be taken.
4. After reviewing the information provided ORR has concluded that, in accordance with the Railways (Accident Investigation and Reporting) Regulations 2005, London Trams and Tram Operations Ltd have:
 - taken the recommendation into consideration; and
 - has taken action to implement it.

Status: Implemented.

Previously reported to RAIB

5. On 4 December 2018 ORR reported the following:

End implementer	Summary of response	Status
Tram Operations Ltd	TOL supported LT's work to introduce step-down speeds on the approach to the areas of the tramway where there is a need to	TOL are supporting the LT project to fit the Croydon tram fleet with a system

	<p>reduce the speed by greater than 30kpmh between the higher and lower speed limits.</p> <p>TOL also supported LT's work to increase the visibility of speed signs, add chevron signs at sharp curves and install digital signage at high risk locations to inform drivers if they are speeding.</p> <p>TOL has played an active role supporting the LT research into an automatic speed reduction system.</p>	<p>that can automatically reduce tram speeds. The project is planning to be completed by December 2019.</p> <p>Status: Implementation on-going</p>
London Trams	<p>LT is in the process of researching and procuring an automatic speed reduction system. The outcome of the research has been shared with other tram owners and operators and UK Tram.</p> <p>LT are planning to have selected a system by December 2018, with full fleet roll out and implementation planned by December 2019. TOL has been working closely with LT on this initiative.</p> <p>LT are also supporting UK Tram research into automatic braking systems.</p>	<p>LT have started a project to fit the Croydon tram fleet with a system that can automatically reduce tram speeds. The project is planning to be completed by December 2019.</p> <p>Status: Implementation on-going</p>

Update

6. On 7 March 2019 Transport for London provided the following update:

In order to determine a suitable automated braking system for retrospective fitment to the London tram fleet, we engaged a specialised consultancy and conducted a global search into appropriate proven technologies. After extensive research into applicable systems the invitation to tender was issued on 31 July 2018 for a physical prevention of over-speeding system (PPOS). TOL were an active stakeholder in this and have supported us in this research. The outcome of the research was shared with other tram owners and operators and UK Tram.

Engineering Support Group (ESG), (a subsidiary of Deutsche Baun, working with Sella have been selected to design and deploy a variant of their Sella's Tracklink 3 product to meet this need. The contract was awarded on 14 December 2018. This system will be set to activate at a safe margin above the posted speed limits at high risk locations. On activation the PPOS will brake a tram to a stop on the basis that a clear over speed violation has occurred. London's tram network will be the first in the UK to have an automatic braking system.

The system will be installed and in operation by the end of 2019, including a period of training and familiarisation with tram drivers ahead of it becoming fully operational.

The new system will initially be configured to priority locations as suggested by the RAIB but will have the flexibility to be introduced elsewhere on the tram network.

In addition, UK Tram have appointed Ian Rowe Associates Ltd (IRAL) to research, identify, and evaluate systems capable of automatically reducing the speed of a tram at high risk locations. IRAL are also carrying out research on behalf of UKTram into driver vigilance devices (recommendation 4). This work analyses the potential impacts, benefits, drawbacks and human factor considerations for each system. The work also considers the practicality, capability and readiness of the various identified solutions. The result of this research is awaited. Together with TOL we will review and evaluate the outcome of this research to determine if any further measures should be taken.

7. On 8 March 2019 Tram Operations Ltd provided the following update

TOL and LT identified two projects to support this recommendation:

- Signage and Speed Reduction – (closed)
- Physical Prevention of over-speeding (PPOS)

The enhanced visibility of signage and speed reduction signs project was completed and closed in Autumn 2017. It also supported RAIB recommendation 5.

Physical Prevention of over-speeding (PPOS)

This is a project currently being led and managed by LT to provide a Physical Prevention of Over-speed System (PPOS). This device is anticipated to be installed over a 14-month period on the infrastructure (track and tram).

During December 2018, LT awarded the contract to implement PPOS to Engineering Support Group (ESG).

TOL and LT are identifying and agreeing the high-risk locations for potential speeding. Recently a review of the visual cues in Croydon Town Centre was carried out and some proposed changes were identified. These changes are being evaluated by LT.

A timeline is being prepared by LT for completion by December 2019. Once the proposed full specification and operational impact is confirmed, TOL will consult with the Trade Union Safety Representatives.

Recommendation 4

The intent of this recommendation is to reduce the likelihood of serious accidents due to tram drivers becoming inattentive because of fatigue or other effects. Existing

tram systems relying on drivers applying forces to driving controls (driver safety devices) do not necessarily detect an inattentive driver. Implementation of this recommendation may be assisted by work in this area already underway by Croydon tramway organisations.

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

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

ORR decision

Edinburgh Trams

8. Since our initial response Edinburgh Trams (ET) have advised us that they have enhanced the settings of the Driver Vigilance and Driver Safety Device to mitigate the risks from driver inattention to the extent that every 400 metres the driver must take a positive action to reset the hardware or an automatically controlled braking of the vehicle will occur. They advised us that additionally they carry out sample reviews of the vehicle data recorder to ensure drivers are driving to the correct speed limit and appropriate use of traction demand and braking is being followed.

9. ORR is seeking more risk based evidence of how the timings of the DVD fitted to the Edinburgh trams have been optimized. This inspection/assurance work will take place during the first half of 2019/20 with a view to potentially moving the status of the recommendation to “implemented”.

10. After reviewing the information provided ORR has concluded that, in accordance with the Railways (Accident Investigation and Reporting) Regulations 2005, Edinburgh Tram has:

- taken the recommendation into consideration; and
- is taking action to implement it.

Status: Implementation ongoing. ORR will advise RAIB when actions to address this recommendation have been completed.

Transport for West Midlands/West Midlands Metro

11. WML commissioned further human factors analysis to optimise the settings on the driver vigilance device.(DVD). MML are undertaking staff consultation on the proposed changes; the tram manufacturer is engineering the changes that will be fitted to all WMM trams.

12. We have asked West Midlands Metro to provide us with the consultants' report that supports the proposed reduction in the threshold of the Driver Vigilance Device (DVD) intervention from 30 to 15 seconds. Once the changes to the tram fleet have been made and staff consultation completed we will be consider the recommendation to be implemented for TfWM/WMM.

13. After reviewing the information provided ORR has concluded that, in accordance with the Railways (Accident Investigation and Reporting) Regulations 2005, TfWM/WMM:

- have taken the recommendation into consideration; and
- are taking action to implement it

Status: Implementation ongoing. ORR will advise RAIB when actions to address this recommendation have been completed.

Previously reported to RAIB

14. On 4 December 2018 ORR reported the following:

End Implementer	Summary of response	Status
Edinburgh Trams	City of Edinburgh Council and Edinburgh Trams are supporting the UKTram research and are awaiting the publication of the report in December 2018. Edinburgh Trams are also discussing possible solutions with their vehicle supplier.	Edinburgh Tram are considering options to address this recommendation, based on their own research and the output from the UKTram research, when completed. Status: Progressing
Transport for West Midlands	The trams used on the West Midlands network have a Driver Vigilance Device (DVD) which will automatically apply the tram brakes if a driver fails to respond to a warning within a set time period. The system is set to fail safe by applying the emergency brakes in the event of a DVD system failure. Currently the DVD is set to test for driver attention every 30s, with brakes being applied if the driver fails to respond by movement of the thumb on the Traction	TfWM/WMM are reviewing the operation of their existing DVD system and awaiting the outcome of the UKTram research. Status: Progressing.

	<p>Brake Controller (TBC) within 4s of the alert.</p> <p>ORR has asked West Midlands Metro to consider reducing the alert interval to 15s and this request is under consideration noting that human factors impacts of a higher frequency of alert.</p> <p>TfWM are monitoring the work being done by UK Tram to review Driver Vigilance Devices and how this may impact on their own work.</p>	
West Midlands Metro	<p>WMM are working with TfWM to consider whether to reduce the frequency of the DVD fitted to their tram fleet from 30s to 15s. An assessment has been completed which included driver behaviour and workload monitoring and a report is currently awaited.</p>	<p>TfWM/WMM are reviewing the operation of their existing DVD system and awaiting the outcome of the UKTram research.</p> <p>Status: Progressing.</p>

Update

15. On 8 March 2019 Transport for West Midlands provided the following update:

MML commissioned Ian Rowe Associates to undertake a human factors analysis of the proposal to reduce the frequency of the Driver Vigilance Device ("DVD") fitted by CAF to the Urbos 3 tram fleet from 30s to 15s. An assessment has been completed which included driver behaviour and workload monitoring and a report has been received. The report supports the proposed reduction in DVD interventions therefore we are in the process of undertaking staff consultation will take place and subject to a satisfactory outcome the change will be implemented. The proposed technical change is currently being manufactured by CAF and will be fitted to all WMM trams.

16. On 19 March 2019 Edinburgh Trams provided the following update:

Edinburgh Trams has reviewed potential solutions provided by the vehicle supplier/maintainer and will consider these further as part of a renewals programme or for new vehicle introduction.

We continues to support the work currently being undertaken by UKTram Subcommittee 1 and we are progressing with our innovation challenge relating to pro-actively monitor and recognise the drivers level of attentiveness.

The D.I.S.C. project is expected to produce a solution within 18 months.

Recommendation 5

The recommendation is intended to provide tram drivers operating on line-of-sight with signage giving visual information cues comparable to those for bus drivers. This recommendation builds on the RAIB's Urgent Safety Advice issued in November 2016 and recognises that driving a tram on line-of-sight has considerable similarities with driving a bus on a public road.

UK tram operators, owners and infrastructure managers, in consultation with the DfT, should work together to review signage, lighting and other visual information cues available on segregated and off-track areas based on an understanding of the information required by drivers on the approach to high risk locations such as tight curves. Comparison should be made with the cues provided to road vehicle drivers on highways that are designed in accordance with current UK highway standards. Prior to the installation of suitable measures to automatically reduce tram speeds at higher risk locations (Recommendation 3) consideration should also be given to providing in-cab warnings to tram drivers on the approach to high risk locations.

The findings of this review should then be used by UK tram operators and tramway owners to improve the information and/or warnings provided to drivers at high risk locations in segregated and off-track areas.

ORR decision

London Trams/Tram Operation Ltd

17. LT/TOL provided a further update on action taken to improve the visual clues provided to tram drivers operating on line of sight principles. This work has included enhancing the visibility of speed signage; additional clues when moving from one speed zone to another, and increased driver assistance in Sandilands Tunnel.

18. We are of the opinion that the initiatives undertaken by LT/TOL have implemented this recommendation. We note that whilst LT have not yet taken account of the output of the UKTram research nor provided evidence of consultation with DfT, significant action has been carried out to review signage provision, enhance it, and provide other visual clues where necessary including adopting best practice solutions from highway.

19. After reviewing the information provided ORR has concluded that, in accordance with the Railways (Accident Investigation and Reporting) Regulations 2005, LT/TOL have:

- taken the recommendation into consideration; and
- taken action to implement it

Status: Implemented.

Previously reported to RAIB

20. On 4 December 2018 ORR reported the following:

End implementer	Summary of response	Status
Tram Operations Ltd	<p>TfL are implementing the iTram system to provide in-cab over speed alerts. Following a successful pilot study TfL have started fitment of the system across the Croydon fleet to be completed by December 2019.</p>	<p>London Trams/TOL have identified an in-cab system to alert the driver to over speeding and have a time-bound plan for fleet fitment by December 2019.</p> <p>Status: Implementation on-going.</p>
London Trams	<p>Following Sandilands, LT installed additional step down speed signage in place in all locations where speeds reduced by 30kph.</p> <p>Maximum speed on the network was reduced from 80kph to 70kph.</p> <p>Where speed signs are located immediately in advance of locations such as tram stops or a marked curve, the sign has been enhanced with the addition of a high visibility outer boarder as an additional cue to drivers of an approaching hazard. Chevrons have been added at sharp curves and installed digital signage at high risk locations to inform drivers if they are speeding.</p> <p>LT/TOL have carried out a route hazard analysis which concluded that the additional speed signage and visual cuing is sufficient.</p> <p>Following the Sandilands incident, additional temporary lighting was installed on the approach to the Sandilands tunnel, while TfL road tunnel lighting experts develop a permanent solution. Work is expected to be complete on the improved tunnel lighting in early 2019.</p>	<p>London Trams/TOL have identified an in-cab system for alert the driver to over speeding and have a time-bound plan for fleet fitment by December 2019.</p> <p>Status: Implementation on-going.</p>

	London Trams/TOL are working together to install the iTram system by December 2019	
--	------------------------------------------------------------------------------------	--

Update

21. On 7 March 2019 Transport for London provided the following update:

As noted in our previous update, together with TOL we reviewed the tunnel lighting levels following feedback from staff and installed additional temporary lighting on the approach to the Sandilands tunnel. This was in addition to providing enhanced visual cues for drivers as reported in our last update. Working with our highway experts within TfL a specification for enhanced tunnel lighting has been developed, adopting best tunnel lighting practice from highways. The new lighting solution will provide comprehensive lighting both within the Sandilands tunnel and also to the tunnel approach at Sandilands Junction. Adoption of latest technologies will link the tunnel lighting to exterior ambient light conditions and will minimise retinal impact to the drivers' vision on tunnel ingress and egress, allowing them to retain the highest levels of visual acuity throughout the tunnel.

An invitation to tender has been released to industry with a return date of end of March 2019. Bidders are incentivised to complete the works by October 2019.

The adoption of highways type road studs ("cats eyes") as a sleeper mounted orientation aid within the Sandilands tunnel is currently being trialled in the Therapia Lane Depot. Subject to acceptance of suitability and reflectivity, the studs will be deployed on the tunnel Up road only to provide differentiation between directions of travel. The studs will also be configured to provide visual orientation between the individual tunnel sections. A network operational trial will commence in March 2019, with overall deployment planned for the same month.

22. On 8 March 2019 Tram Operations Ltd provided the following update:

TOL believe there are three activities that support this RAIB recommendation. All were or are being project managed by LT with TOL providing operational input.

- *Enhanced visibility of speed control signs (closed)*
- *Update signage and other visual cues (signage closed)*
- *Review of tunnel lighting*

The enhanced visibility of speed control signs and signage project was completed and closed in Autumn 2017. This project also supports RAIB recommendation 3.

Update other visual cues – such as directional (orientation) assistance and

moving between different speed zones.

During 2018, following further assessment, LT and TOL confirmed a requirement for additional visual cues on the network and jointly agreed that directional 'cats eyes' in Sandilands tunnel would be implemented.

LT set up a project to implement the 'cats eyes'; and TOL has provided operational input. LT and TOL have jointly agreed to install. The intention is to install a combination of different colours of 'cats eyes, e.g. amber and white in the three tunnel section at Sandilands tunnel.

The cats eyes were tested in the sidings at the Therapia Lane depot for 2 weeks at the end of January 2019. The test results will be reviewed, and the outcome used to shape installation moving forward. It is anticipated these will be installed during the spring of 2019.

An updated briefing document will be prepared and discussed with staff and Unions prior to installation.

Review of tunnel lighting

During 2018, LT and TOL carried out a review of the lighting in the Sandilands tunnel. Whilst this was not part of the original Sandilands findings, TOL and LT took a decision to review tunnel lighting levels, following feedback about safety concerns from staff, and implemented a temporary solution.

Having identified the issue a temporary solution was installed, and LT are leading on the project for a permanent solution with a target installation date of end of 2019.

iTram (a business as usual joint project between LT and TOL)

LT are leading another project called iTram. Dry installation is complete on 13 trams to date. Technical issues related to remote downloading of information and integration with Vecom systems have delayed full integration of iTram into the vehicles.

Initially iTram will alert the driver via in cab alarms with speed management warnings only. It will otherwise be passive to the driver.

TOL is preparing a briefing for Unions and drivers.

Recommendation 7

The intent of this recommendation is to provide emergency lighting which will operate without connection to remote power supplies such as the tram's main batteries and the overhead electrical supply. Implementation may involve tram operators seeking input from appropriate tram manufacturers.

UK tram operators and owners should install (or modify existing) emergency lighting so that the lighting cannot be unintentionally switched off or disconnected during an emergency.

ORR decision

London Trams/Tram Operation Ltd

23. LT/TOL have made arrangements for the fitment of a new emergency lighting system to the Croydon tram fleet, to be completed by June 2019. The system will be able to provide emergency lighting using its own power, independent of the trams batteries or power supply.

24. After reviewing the information provided ORR has concluded that, in accordance with the Railways (Accident Investigation and Reporting) Regulations 2005, LT/TOL has:

- taken the recommendation into consideration; and
- is taking action to implement it by June 2019.

Status: Implementation ongoing. ORR will advise RAIB when actions to address this recommendation have been completed.

Transport for Greater Manchester/Manchester Metrolink Ltd

25. TfGM/MML have included emergency lights which will operate independently of the tram power supply in the specification for the new Metrolink tram fleet. The emergency lighting on the existing fleet will last for approximately 45 minutes with a set of full batteries.

26. After reviewing the information provided ORR has concluded that, in accordance with the Railways (Accident Investigation and Reporting) Regulations 2005, TfGM/MML has:

- taken the recommendation into consideration; and
- taken action to implement it.

Status: Implemented.

Previously reported to RAIB

27. On 4 December 2018 ORR reported the following:

End Implementer	Summary of response	Status
Tram Operations Ltd	LT are leading a project to investigate options to replace the emergency lighting in the existing tram fleet, with operational and driver input from TOL as required. LT and TOL have developed a scope of requirements and an invitation to tender has been issued.	TOL/LT have a developed a programme for upgrading the emergency lighting on the Croydon fleet, but have not yet finalised a time-bound plan for completion of the work Status: Progressing.
London Trams	LT and TOL have developed a scope of requirements for retrofitting emergency lighting and an invitation to tender has been issued. The system will be fully autonomous, and will operate independently of the trams battery system in the event of an emergency. Finding s will be shared with industry through UKTram subcommittee 1.	TOL/LT have a developed a programme for upgrading the emergency lighting on the Croydon fleet, but have not yet finalised a time-bound plan for completion of the work Status: Progressing.
Transport for Greater Manchester	TfGM is exploring possibilities to modify the emergency on board lighting with the tram suppliers.	TfGM/KAM are awaiting the output of the industry risk model before making any changes to the emergency lighting on their tram fleet Status: Progressing.
Manchester Metrolink	The emergency lighting on the existing KAM fleet will remain lit, with a full set of batteries for approximately 45 minutes. KAM will review the recommendation with their vehicle supplier, to determine if any	TfGM/KAM are awaiting the output of the industry risk model before making any changes to the

	modifications can be made to make them more robust.	emergency lighting on their tram fleet Status: Progressing.
--	-----------------------------------------------------	-------------------------------------------------------------------------------

Update

28. On 7 March 2019 Transport for London provided the following update:

We have awarded a contract for the design and provision of emergency lighting to the tram fleet. This system will provide additional lighting units within the tram equipped with autonomous batteries. In the event of the tram's own batteries or lighting circuits becoming unavailable, the new system will provide suitable illumination throughout the tram. TOL supported us in the development of the design and scope of requirements with operational and driver input.

Design of the new system is underway, with fleet roll out planned between March and June 2019.

29. On 8 March 2019 Tram Operations Ltd provided the following update:

During December 2018, LT appointed Orion Rail to replace the standby emergency lighting in all trams.

A completed design is expected by end of April 2019 with installation expected to be completed by end of June 2019.

When the final design is available TOL will review any operational impact with Trade Unions and drivers. TOL will also be involved to help minimise impact on customers and operations of the service, when LT implement the chosen emergency lighting solution in the trams.

30. On 8 March 2019 Transport for Greater Manchester (TfGM) and Keolis Amey Metrolink (KAM) provided the following joint update:

A review of on-board emergency lighting has been carried out, in the design of the new trams for Metrolink, which has resulted in the inclusion of LED lights, with an independent power source on some of the lighting units recommended. This solution will continue to be developed during the design reviews and procurement activities. We are therefore satisfied that the new trams will come with a solution that meets the intent of this recommendation and will look to develop a case to retrofit the existing fleet with the same LED lighting solution.

The emergency lighting on the existing fleet will last for approximately 45 minutes with a set of full batteries.

Recommendation 10

This recommendation is intended to ensure that Tram Operations Limited's systems for identifying the hazards and assessing the risk associated with its operation are fit for purpose. The requirement for an independent review does not prevent it being carried out by other parts of TfL and FirstGroup provided the requisite expertise is available.

Tram Operations Limited and London Trams should commission an independent review of its process for assessing risk associated with the operation of trams (e.g. collision, derailment and overturning of trams). This review shall consider:

- i. the extent to which the process for risk assessments is capable of identifying and correctly assessing all significant risks, particularly those related to low frequency/high consequence events; and
- ii. the means by which potential mitigations are identified and evaluated.

The findings of the review shall be incorporated into a documented process for the assessment of operational risk. This should also be shared with other tramways.

ORR decision

London Trams/Tram Operation Ltd

31. LT/TOL have shared with us the document 'Management of the London Trams Safety Risk Model', which demonstrates that they have a process in place to monitor operational risk.

32. After reviewing the information provided ORR has concluded that, in accordance with the Railways (Accident Investigation and Reporting) Regulations 2005, LT/TOL have:

- taken the recommendation into consideration; and
- taken action to implement it.

Status: Implemented.

Previously reported to RAIB

33. On 4 December 2018 ORR reported the following:

The Tram Safety Risk Model for the Croydon system is owned and managed by London Trams. The model considers all aspects of system risk associated with operating trams on the Croydon Tramlink, using a series of hazardous events and precursors to record risk controls, potential consequences, FWI rating and distribution of harm. Where appropriate TOL's safety management procedures form inputs to the model and are recorded as risk controls. Following the Sandilands Accident, London Trams reviewed and updated the risk model, with the assistance of TOL.

TOL's key input to the model are Route Hazard Assessments. TOL are responsible for assessing and documenting hazards associated with line of sight driving; and communicating the findings of these assessments - including the risk controls, to its drivers. TOL have developed a safety management procedure (Route Knowledge for Tram Drivers) which specifies the process used.

The performance execution plan for review of the Route Hazard Assessments, safety management procedure and updated route hazard assessment information for each line of route driven over have been shared with ORR.

We have asked TOL to demonstrate how they are bringing together the output from this work with other work streams, such as Bow Tie analysis and general risk assessments, in order to ensure the robustness of their processes for identifying the hazards and assessing the risks associated with its operation.

We will consider the recommendation to have been implemented once TOL have demonstrated how the different work streams deliver a single, robust process for identifying hazards and assessing operational risks.

Update

34. On 7 March 2019 Transport for London provided the following update:

As previously reported we worked collaboratively with TOL to review and update our safety risk model. The annual review of this model is currently underway and will be completed by the end of March 2019.

Following TOL's review of their route risk assessment and the joint review of the safety model, we are working with TOL to develop simulator technology, interactive scenarios and simulated events to support driver training and in the management of risks such as collisions and derailments.

35. On 8 March 2019 Tram Operations Ltd provided the following update:

This recommendation is directed to both TOL and LT. There were two projects that meet RAIB 10 and details of each are provided below:

Safety Bow-Tie Risk Assessment

TOL and LT completed their Safety Bow-Tie Risk Assessment and Risk Modelling in 2018. The safety bow-tie risk assessment continues to be a key contributor to the Joint Risk Model. It has been embedded into both businesses and continues to be reviewed and assessed as part of the joint LT / TOL governance process.

Joint Risk Model

The Joint Risk Model is in use on a day-to-day basis, as required. TOL and LT have integrated the use of the Model into each company's change management processes. The annual review of the model was held on 26th February 2019.

A process is being developed to demonstrate how these two work streams deliver a single, robust process for identifying hazards and assessing operational risks.

The new industry model is being developed by UKTram and is expected to be in place during 2020.

Previously reported to RAIB

Recommendation 3

The intent of this recommendation is to prevent serious accidents due to excessive speed at higher risk locations on tramways. These locations are likely to include all locations where a substantial speed reduction is required for trams approaching at relatively high speed. Implementation of this recommendation may be assisted by work in this area already underway by Croydon tramway organisations.

UK tram operators, owners and infrastructure managers should work together to review, develop, and provide a programme for installing suitable measures to automatically reduce tram speeds if they approach higher risk locations at speeds which could result in derailment or overturning

1. The action taken by each duty holder and the ORR view on if it addresses the recommendation is summarized in the table below.

End implementer	Summary of response	Status
Tram Operations Ltd	<p>TOL supported LT's work to introduce step-down speeds on the approach to the areas of the tramway where there is a need to reduce the speed by greater than 30kpmh between the higher and lower speed limits.</p> <p>TOL also supported LT's work to increase the visibility of speed signs, add chevron signs at sharp curves and install digital signage at high risk locations to inform drivers if they are speeding.</p> <p>TOL has played an active role supporting the LT research into an automatic speed reduction system.</p>	<p>TOL are supporting the LT project to fit the Croydon tram fleet with a system that can automatically reduce tram speeds. The project is planning to be completed by December 2019.</p> <p>Status: Implementation on-going</p>
London Trams	<p>LT is in the process of researching and procuring an automatic speed reduction system. The outcome of the research has been shared with other tram owners and operators and UK Tram.</p> <p>LT are planning to have selected a system by December 2018, with full fleet roll out and implementation planned by December 2019. TOL has been working closely with LT on this initiative.</p>	<p>LT have started a project to fit the Croydon tram fleet with a system that can automatically reduce tram speeds. The project is planning to be completed by December 2019.</p>

	LT are also supporting UK Tram research into automatic braking systems.	Status: Implementation on-going
Blackpool Borough Council	Blackpool Transport Services, together with Blackpool Borough Council's tram promoter is conducting a trial of a Bombardier system which will initially be used for obstacle detection on moving trams, and may in future be able to be used for controlling tram overspeeding	Blackpool Borough Council are considering options to address this recommendation, based on their own research and the output from the UKTram research when completed. Status: Progressing.
Blackpool Transport Services	Blackpool Transport Services is participating in a trial of a Bombardier system which will initially be used for obstacle detection on moving trams, and may in future be able to be used for controlling tram overspeeding.	BTS are considering options to address this recommendation, based on their own research and the output from the UKTram research when completed. Status: Progressing.

Recommendation 4

The intent of this recommendation is to reduce the likelihood of serious accidents due to tram drivers becoming inattentive because of fatigue or other effects. Existing tram systems relying on drivers applying forces to driving controls (driver safety devices) do not necessarily detect an inattentive driver. Implementation of this recommendation may be assisted by work in this area already underway by Croydon tramway organisations.

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

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

2. The action taken by each duty holder and the ORR view on if it addresses the recommendation is summarized in the table below.

End Implementer	Summary of response	Status
Transport for West Midlands	<p>The trams used on the West Midlands network have a Driver Vigilance Device (DVD) which will automatically apply the tram brakes if a driver fails to respond to a warning within a set time period. The system is set to fail safe by applying the emergency brakes in the event of a DVD system failure.</p> <p>Currently the DVD is set to test for driver attention every 30s, with brakes being applied if the driver fails to respond by movement of the thumb on the Traction Brake Controller (TBC) within 4s of the alert.</p> <p>ORR has asked West Midlands Metro to consider reducing the alert interval to 15s and this request is under consideration noting that human factors impacts of a higher frequency of alert.</p> <p>TfWM are monitoring the work being done by UK Tram to review Driver Vigilance Devices and how this may impact on their own work.</p>	<p>TfWM/WMM are reviewing the operation of their existing DVD system and awaiting the outcome of the UKTram research.</p> <p>Status: Progressing.</p>
West Midlands Metro	<p>WMM are working with TfWM to consider whether to reduce the frequency of the DVD fitted to their tram fleet from 30s to 15s. An assessment has been completed which included driver behaviour and workload monitoring and a report is currently awaited.</p>	<p>TfWM/WMM are reviewing the operation of their existing DVD system and awaiting the outcome of the UKTram research.</p> <p>Status: Progressing.</p>

Recommendation 5

The recommendation is intended to provide tram drivers operating on line-of-sight with signage giving visual information cues comparable to those for bus drivers. This recommendation builds on the RAIB's Urgent Safety Advice issued in November 2016 and recognises that driving a tram on line-of-sight has considerable similarities with driving a bus on a public road.

UK tram operators, owners and infrastructure managers, in consultation with the DfT, should work together to review signage, lighting and other visual information cues available on segregated and off-track areas based on an understanding of the information required by drivers on the approach to high risk locations such as tight curves. Comparison should be made with the cues provided to road vehicle drivers on highways that are designed in accordance with current UK highway standards. Prior to the installation of suitable measures to automatically reduce tram speeds at higher risk locations (Recommendation 3) consideration should also be given to providing in-cab warnings to tram drivers on the approach to high risk locations.

The findings of this review should then be used by UK tram operators and tramway owners to improve the information and/or warnings provided to drivers at high risk locations in segregated and off-track areas.

3. The action taken by each duty holder and the ORR view on if it addresses the recommendation is summarized in the table below.

End implementer	Summary of response	Status
Tram Operations Ltd	TfL are implementing the iTram system to provide in-cab over speed alerts. Following a successful pilot study TfL have started fitment of the system across the Croydon fleet to be completed by December 2019.	London Trams/TOL have identified an in-cab system to alert the driver to over speeding and have a time-bound plan for fleet fitment by December 2019. Status: Implementation on-going.
London Trams	Following Sandilands, LT installed additional step down speed signage in place in all locations where speeds reduced by 30kph. Maximum speed on the network was reduced from 80kph to 70kph. Where speed signs are located immediately in advance of locations such as tram stops	London Trams/TOL have identified an in-cab system for alert the driver to over speeding and have a time-bound plan for fleet fitment by December 2019.

	<p>or a marked curve, the sign has been enhanced with the addition of a high visibility outer boarder as an additional cue to drivers of an approaching hazard. Chevrons have been added at sharp curves and installed digital signage at high risk locations to inform drivers if they are speeding.</p> <p>LT/TOL have carried out a route hazard analysis which concluded that the additional speed signage and visual cuing is sufficient.</p> <p>Following the Sandilands incident, additional temporary lighting was installed on the approach to the Sandilands tunnel, while TfL road tunnel lighting experts develop a permanent solution. Work is expected to be complete on the improved tunnel lighting in early 2019.</p> <p>London Trams/TOL are working together to install the iTram system by December 2019</p>	<p>Status: Implementation on-going.</p>
--	----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	-----------------------------------------------------------

Recommendation 7

The intent of this recommendation is to provide emergency lighting which will operate without connection to remote power supplies such as the tram's main batteries and the overhead electrical supply. Implementation may involve tram operators seeking input from appropriate tram manufacturers.

UK tram operators and owners should install (or modify existing) emergency lighting so that the lighting cannot be unintentionally switched off or disconnected during an emergency.

- The action taken by each duty holder and the ORR view on if it addresses the recommendation is summarized in the table below.

End Implementer	Summary of response	Status
-----------------	---------------------	--------

Tram Operations Ltd	LT are leading a project to investigate options to replace the emergency lighting in the existing tram fleet, with operational and driver input from TOL as required. LT and TOL have developed a scope of requirements and an invitation to tender has been issued.	TOL/LT have a developed a programme for upgrading the emergency lighting on the Croydon fleet, but have not yet finalised a time-bound plan for completion of the work Status: Progressing.
London Trams	LT and TOL have developed a scope of requirements for retrofitting emergency lighting and an invitation to tender has been issued. The system will be fully autonomous, and will operate independently of the trams battery system in the event of an emergency. Finding s will be shared with industry through UKTram subcommittee 1.	TOL/LT have a developed a programme for upgrading the emergency lighting on the Croydon fleet, but have not yet finalised a time-bound plan for completion of the work Status: Progressing.
Transport for Greater Manchester	TfGM is exploring possibilities to modify the emergency on board lighting with the tram suppliers.	TfGM/KAM are awaiting the output of the industry risk model before making any changes to the emergency lighting on their tram fleet Status: Progressing.
Manchester Metrolink	The emergency lighting on the existing KAM fleet will remain lit, with a full set of batteries for approximately 45 minutes. KAM will review the recommendation with their vehicle supplier, to determine if any modifications can be made to make them more robust.	TfGM/KAM are awaiting the output of the industry risk model before making any changes to the emergency lighting on their tram fleet

		Status: Progressing.
--	--	---------------------------------

Recommendation 10

This recommendation is intended to ensure that Tram Operations Limited's systems for identifying the hazards and assessing the risk associated with its operation are fit for purpose. The requirement for an independent review does not prevent it being carried out by other parts of TfL and FirstGroup provided the requisite expertise is available.

Tram Operations Limited and London Trams should commission an independent review of its process for assessing risk associated with the operation of trams (e.g. collision, derailment and overturning of trams). This review shall consider:

- i. the extent to which the process for risk assessments is capable of identifying and correctly assessing all significant risks, particularly those related to low frequency/high consequence events; and
- ii. the means by which potential mitigations are identified and evaluated.

The findings of the review shall be incorporated into a documented process for the assessment of operational risk. This should also be shared with other tramways.

ORR decision

5. The Tram Safety Risk Model for the Croydon system is owned and managed by London Trams. The model considers all aspects of system risk associated with operating trams on the Croydon Tramlink, using a series of hazardous events and precursors to record risk controls, potential consequences, FWI rating and distribution of harm. Where appropriate TOL's safety management procedures form inputs to the model and are recorded as risk controls. Following the Sandilands Accident, London Trams reviewed and updated the risk model, with the assistance of TOL.

6. TOL's key input to the model are Route Hazard Assessments. TOL are responsible for assessing and documenting hazards associated with line of sight driving; and communicating the findings of these assessments - including the risk controls, to its drivers. TOL have developed a safety management procedure (Route Knowledge for Tram Drivers) which specifies the process used.

7. The performance execution plan for review of the Route Hazard Assessments, safety management procedure and updated route hazard assessment information for each line of route driven over have been shared with ORR.

8. We have asked TOL to demonstrate how they are bringing together the output from this work with other work streams, such as Bow Tie analysis and general risk

assessments, in order to ensure the robustness of their processes for identifying the hazards and assessing the risks associated with its operation.

9. We will consider the recommendation to have been implemented once TOL have demonstrated how the different work streams deliver a single, robust process for identifying hazards and assessing operational risks.

10. After reviewing the information provided ORR has concluded that, in accordance with the Railways (Accident Investigation and Reporting) Regulations 2005, TOL has:

- taken the recommendation into consideration; and
- has done a significant amount of work in this area across multiple work streams and is working to refine this into an over-arching process

Status: Implementation on-going. ORR will advise RAIB when further information is available regarding actions being taken to address this recommendation.