MAYOR OF LONDON

TRANSPORT FOR LONDON
EVERY JOURNEY MATTERS

Agenda

Meeting: Safety, Sustainability and Human Resources Panel

Date: Wednesday 4 September 2019

Time: 10.00am

Place: Conference Rooms 1 and 2, Ground Floor, Palestra, 197 Blackfriars Road, London, SE1 8NJ

Members

Kay Carberry CBE (Chair)
Dr Nina Skorupska CBE (Vice-Chair)
Bronwen Handyside
Dr Mee Ling Ng OBE
Mark Phillips

Copies of the papers and any attachments are available on tfl.gov.uk How We Are Governed.

This meeting will be open to the public, except for where exempt information is being discussed as noted on the agenda. There is access for disabled people and induction loops are available. A guide for the press and public on attending and reporting meetings of local government bodies, including the use of film, photography, social media and other means is available on www.london.gov.uk/sites/default/files/Openness-in-Meetings.pdf.

Further Information

If you have questions, would like further information about the meeting or require special facilities please contact: James Varley, Secretariat Officer, 020 7983 4613; email: JamesVarley@TfL.gov.uk.

For media enquiries please contact the TfL Press Office; telephone: 0343 222 4141; email: PressOffice@tfl.gov.uk

Howard Carter, General Counsel
Tuesday 27 August 2019

Agenda
Safety, Sustainability and Human Resources Panel
Wednesday 4 September 2019

1 Apologies for Absence and Chair's Announcements

2 Declarations of Interests

General Counsel

Members are reminded that any interests in a matter under discussion must be declared at the start of the meeting, or at the commencement of the item of business.

Members must not take part in any discussion or decision on such a matter and, depending on the nature of the interest, may be asked to leave the room during the discussion.

3 Minutes of the Meeting of the Panel held on 10 July 2019 (Pages 1 - 8)

General Counsel

The Panel is asked to approve the minutes of the meeting of the Panel held on 10 July 2019 and authorise the Chair to sign them.

4 Matters Arising and Actions List (Pages 9 - 12)

General Counsel

The Panel is asked to note the updated actions list.

5 Tram Overturning at Sandilands, Croydon on 9 November 2016 - Update (Pages 13 - 30)

Managing Director, Surface Transport

The Panel is asked to note the report.

6 Quarterly Health, Safety and Environment Performance Report (Pages 31 - 124)

Director of Health, Safety and Environment

The Panel is asked to note the report.

7 Bus Safety Programme (Pages 125 - 280)

Managing Director, Surface Transport

The Panel is asked to note the paper.

8 Bus Driver Facility Improvements (Pages 281 - 288)

Managing Director, Surface Transport

The Panel is asked to note the paper.

9 Increasing the Maturity of our Health Safety Environment Management System (Pages 289 - 298)

Director of Health, Safety and Environment

The Panel is asked to note the paper.

10 Major Events (Pages 299 - 302)

Managing Director, Surface Transport

The Panel is asked to note the paper.

11 Pan TfL People Plan 2019/20 (Pages 303 - 318)

Chief People Officer

The Panel is asked to note the paper.

12 Human Resources Quarterly Report (Pages 319 - 334)

Chief People Officer

The Panel is asked to note the report.

13 Disability Roadmap (Pages 335 - 350)

Director of Diversity, Inclusion and Talent

The Panel is asked to note the paper.

14 Active People Plan Update (Pages 351 - 362)

Director of City Planning

The Panel is asked to note the paper.

15 Workplace Parking Levies (Pages 363 - 374)

Director of City Planning

The Panel is asked to note the paper.

16 Strategic Risk Update - TfL's Environmental Impact (SR14) (Pages 375 - 378)

Director of City Planning

The Panel is asked to note the paper and the supplemental information on Part 2 of the agenda.

17 Strategic Risk Update - Resilience to Climate Change and Extreme Weather (SR15) (Pages 379 - 382)

Director of City Planning

The Panel is asked to note the paper and the supplemental information on Part 2 of the agenda.

18 Transformation Programme Update (Pages 383 - 384)

Transformation Director

The Panel is asked to note the paper.

19 Member Suggestions for Future Agenda Discussions (Pages 385 - 388)

General Counsel

The Panel is asked to note the forward programme and is invited to raise any suggestions for future discussion items for the forward programme, the Panel's induction and for informal briefings.

20 Any Other business the Chair Considers Urgent

The Chair will state the reason for urgency of any item taken.

21 Date of Next Meeting

Wednesday 13 November 2019 at 10.00am

22 Exclusion of Press and Public

The Panel is recommended to agree to exclude the press and public from the meeting, in accordance with paragraphs 1 and 2 of Schedule 12A to the Local Government Act 1972 (as amended), in order to consider the following items of business.

23 Strategic Risk Update - TfL's Environmental Impact (SR14) - Exempt Information (Pages 389 - 398)

Director, City Planning

Exempt Supplementary Information relating to the item on Part 1 of the agenda.

24 Strategic Risk Update - Resilience to Climate Change and Extreme Weather (SR15) - Exempt Information (Pages 399 - 408)

Director, City Planning

Exempt Supplementary Information relating to the item on Part 1 of the agenda.

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Transport for London

Minutes of the Safety, Sustainability and Human Resources Panel

Conference Rooms 1 and 2, Ground Floor, Palestra, 197 Blackfriars Road, London, SE1 8NJ
10.00am, Wednesday 10 July 2019

Members

Kay Carberry CBE (Chair)
Bronwen Handyside
Dr Mee Ling Ng CBE

In Attendance

Rachel Cary	Policy and Programmes Manager, GLA
Shirley Rodrigues	Deputy Mayor for Environment and Energy

Executive Committee

Staynton Brown	Director of Diversity, Inclusion and Talent
Nigel Holness	Managing Director, London Underground
Andrew Pollins	Transformation Director
Alex Williams	Director, City Planning
Tricia Wright	Chief People Officer

Present

Claudina Castelli	Senior Risk Manager
Andrea Clarke	Director of Legal
Jill Collis	Director of Health, Safety and Environment
Dan Curry	Energy and Carbon Strategy Manager
Siwan Hayward OBE	Director of Compliance, Policing and On-street Services
Philip Hewson	Head of Procurement, Strategy and Performance
James Ingram	Principal City Planner
Paul Kiteley	Senior Commercial Manager
Glyn Lenton	Commercial Manager
Mike Shirbon	Head of Integrated Assurance
James Varley	Secretariat Officer

18/07/19 Apologies for Absence and Chair's Announcements

Apologies for absence had been received from Dr Nina Skorupska CBE and Mark Phillips. Howard Carter and Gareth Powell were also unable to attend.

Safety is paramount to TfL and accordingly, at the start of all meetings attended by Board Members, Members are asked to raise any safety issues relating to items on the agenda or in general. Members confirmed there were no safety matters they wished to raise other than those to be discussed on the agenda.

19/07/19 Declarations of Interests

Members confirmed that their declarations of interests, as published on tfl.gov.uk, were up to date and there were no interests that related specifically to items on the agenda.

20/07/19 Minutes of the Meeting of the Panel held on 27 February 2019

The minutes of the meeting were approved as a correct record and were signed by the Chair.

21/07/19 Matters Arising and Actions List

Andrea Clarke introduced the item.

Members requested that an update be provided to a future meeting on the process of embedding the low carbon agenda into TfL's decision making process.

[Action: Alex Williams]

A recent meeting with the Office of Rail and Road concluded that it was not necessary for a wider review of legislation at this stage but this position would be reviewed periodically.

The Panel noted the actions list.

22/07/19 Quarterly Health, Safety and Environment Performance Reports

Jill Collis introduced the report, which provided an overview of health, safety and environmental performance for London Underground, TfL Rail, Surface Transport (including London Overground) and Crossrail for Quarter 4 2018/19 (9 December 2018 to 31 March 2019).

Overall, customer injuries on the network had decreased by five per cent, a substantial reduction being seen on buses against a slight rise on London Underground which correlated to an increase in passenger numbers. Mitigating activities were taking place to address this.

The number of people killed or seriously injured in 2018 decreased by 16 per cent against the previous year and work was underway to ensure the Vision Zero targets would be met. Research on road risk was being commissioned with the Transport Research Laboratory, with the results due later in the year; which would provide a more detailed methodology and analysis of risk.

In response to a question from a Member, information would be provided on bus driver engagement with Vision Zero and the introduction of the Mobileye collision avoidance system. **[Action: Gareth Powell]**

Health, Safety and Environment training was progressing well. It was aimed at anyone who managed or supervised service delivery, maintenance, people or projects. To date, 3,035 staff had started the course with 67 per cent having completed it.

There had been an increase in environmental incidents against Quarter 4 2017/18. The majority of incidents were categorised as small incidents with low risk and work was underway to reverse the trend.

Noise complaints had also increased and Members encouraged officers to view the affects of noise from a customer perspective as well as a safety matter.

The ability of TfL to set out sustainability requirements when planning and working with events organisers was being actively addressed and an update was on the forward plan for the next meeting.

Clarification was sought on the governance arrangements for Tramlink Operations Limited management of fatigue and an update would be provided to a future meeting. **[Action: Jill Collis]**

The Panel noted the report.

23/07/19 Workplace Violence and Aggression Summit Update

Siwan Hayward introduced the item, which provided an update on the summit that took place on 19 March 2019.

The summit and a follow up staff workshop were part of an approach to promote activities across TfL, its suppliers and its contractors. The emerging strategy would look at prevention of violence and aggression, support for staff and achieve excellence through constant improvement.

The impact of workplace violence on mental health was well understood and was linked to the development of the Health and Wellbeing Strategy.

Further information on the engagement and work with the trade unions would be provided. **[Action: Siwan Hayward OBE]**

The Panel noted the paper.

24/07/19 Responsible Procurement

Philip Hewson and Paul Kiteley introduced the item, which set out the draft Slavery and Human Trafficking Statement and the steps being taken to investigate and mitigate the risks of slavery in the business and its supply chain.

Work was being undertaken to develop an assurance process. A range of activities would take place including reviews of compliance checks of supplier Slavery Statements, questionnaires for key suppliers and desk based audits. Results of these exercises would be used to help improve protection methods.

There was also a focus on creating and building social value on shorter UK / EU based supply chains.

The draft Slavery and Human Trafficking Statement would be submitted to the meeting of the Board on 24 July 2019 for approval.

The Panel noted the paper.

25/07/19 Energy Strategy

Alex Williams, Dan Curry, James Ingram and Glyn Lenton introduced the item, which provided an update on progress of the Energy and Carbon Reduction Strategy.

There were four workstreams in the energy programme that focussed on energy efficiency, energy generation, procurement and road transport electrification.

Work on TfL's carbon commitments arising from the Mayor's Transport Strategy and London Environment Strategy was progressing well for the zero emission bus fleet and reductions on TfL Corporate CO_2 emissions. It was noted that additional action was required to reach the 2030 target for TfL controlled rail services to be zero carbon.

It was suggested that increasing the efficiency of head office buildings should be prioritised and consideration should be given to reviewing the decision making process when looking at the timing of upgrading building infrastructure.

Members emphasised the need for the strategy to be embedded in all significant programmes and activities undertaken by TfL.

Procurement of renewable energy from the grid was being reviewed, with market engagement to help understand the procurement route and value for money implications of Power Purchase Agreements. In addition, TfL was working with Crown Commercial Services to identify further opportunities.

The Board would be discussing the Energy and Carbon Strategy as part of its business planning discussions. An update on electrification of the bus network would be provided to the next meeting on 4 September and a strategy update would be provided to the meeting on 13 November 2019.

The Panel noted the paper.

26/07/19 Human Resources Quarterly Report

Tricia Wright introduced the report, which provided an overview on key Human Resources led activities and statistics from Quarter 4 2018/19 (9 December 2018 to 31 March 2019).

The all staff representativeness index for the year was 69.39 per cent, just below target of 70.7 per cent and above last year's score of 69.7 per cent. Director and Band 5 representativeness was 37.8 per cent against a target of 46.6 per cent. The two key factors behind this were the rebaselining of data relating to the economically active

population which increased the percentage of BAME population from 32 per cent to 36 per cent and also higher rates of disclosure following a successful campaign. Recruitment in general and to apprentice and graduate programmes had seen considerable success in achieving improved workforce composition.

Females remained over represented in the leavers data and analysis was underway to understand this.

The disclosure campaign had gone well, particularly for gender and ethnicity and it was noted that further work was needed to increase disability disclosure.

The Panel noted the report.

27/07/19 Employee Engagement Update

Tricia Wright introduced the paper, which provided an update on activity taking place to improve employee engagement.

In 2018, employee engagement, as measured by the Total Engagement Index, remained at 56 per cent, just below the Scorecard target of 57 per cent.

TfL was committed to being a great place to work with a comprehensive approach to engagement. Work was underway to ensure that the right tools and training were available and to understand which activities had the greatest impact.

The Panel noted the report.

28/07/19 Diversity and Inclusion Dashboard Update

Staynton Brown introduced the paper, which provided an update on the use of the dashboards to underpin work on diversity and inclusion.

The dashboards delivered a picture of how effective actions were across the organisation and across the employee life cycle. They also indicated how effective targeted recruitment campaigns had been. In addition, they helped build awareness and informed equality impact assessments.

Work would take place to consider how a commentary could complement the data provided. **[Action: Staynton Brown]**

29/07/19 Health and Wellbeing Strategy

Staynton Brown introduced the paper, which provided an update on the proposals to create a Health and Wellbeing Strategy.

The strategy would be an integral part of the People Strategy and would take a holistic view of health and wellbeing. It would assist in developing a better understanding of the workforce and its needs and identify where resource and focus was required.

Delivery of the strategy would use technology such as apps which would also enable tracking of indices to measure the overall wellbeing of staff.

The Panel noted the paper.

30/07/19 Strategic Risk Update – Talent Attraction and Retention

Tricia Wright introduced the item, including the exempt information on Part 2 of the agenda, which informed the Panel of work undertaken and planned to control risk relating to the attraction, recruitment, engagement, development and retaining of talent in key competencies.

The Panel noted the paper and the supplementary information on Part 2 of the agenda.

31/07/19 Transformation Programme Update

Andrew Pollins introduced the item, which provided an update on the Transformation programme.

The Panel noted the paper.

32/07/19 Member Suggestions for Future Agenda Items

Andrea Clarke introduced the item. Reports on the bus electrification programme, Loughborough University Fatigue Research and Energy and Carbon Strategy would be added to the forward plan.

The Panel noted the forward plan.

33/07/19 Any Other Business the Chair Considers Urgent

There was no urgent business.

34/07/19 Date of Next Meeting

The next scheduled meeting of the Panel would be held on Wednesday 4 September 2019 at 10.00am.

35/07/19 Exclusion of the Press and Public

The Panel agreed to exclude the press and public from the meeting, in accordance with paragraph 3 of Schedule 12A to the Local Government Act 1972 (as amended), when it considered the exempt information in relation to the item on: Update on Strategic Risk - Talent Attraction and Retention

36/07/19 Close of Meeting

The meeting closed at 12.45pm.

Chair: _____

Date: _____

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Safety, Sustainability and Human Resources Panel

Date: **4 September 2019**

Item: **Actions List**

This paper will be considered in public

1 Summary

1.1 This paper informs the Panel of progress against actions agreed at previous meetings.

2 Recommendation

2.1 **The Panel is asked to note the Actions List.**

List of appendices to this report:

Appendix 1: Actions List

List of Background Papers:

Minutes of previous meetings of the Panel

Contact Officer: Howard Carter, General Counsel
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Appendix 1

Safety, Sustainability and Human Resources Panel Actions List (reported to the meeting on 4 September 2019)

Actions from the meeting held on 10 July 2019

Minute No.	Description	Action By	Target Date	Status/note
21/07/19	**Matter Arising and Actions List** Provide an update on embedding the low carbon agenda in the decision making process.	Alex Williams	13 November 2019	On agenda forward plan
22/07/19 (2)	**Quarterly Health, Safety and Environment Report: Tramlink Operations** Clarify the governance arrangements for management of fatigue.	Jill Collis	4 September 2019	Since the tragic incident at Sandilands junction, fatigue management indicators have been part of the Trams Safety Performance Index (SPI) measure. As such fatigue management monitoring is reviewed as part of the SPI, together with other emerging risks on a precursors basis - . anticipating risk rather than responding to it. This is on a four-weekly basis as part of our Trams and Rail and Sponsored Services safety governance meetings chaired by the TfL General Manager of Trams and the Director of Rail and Sponsored Services respectively.

Minute No.	Description	Action By	Target Date	Status/note
23/07/19	**Workplace Violence and Aggression Summit Update** Provide further information on engagement with trades unions.	Siwan Hayward	17 July 2019	Completed. Email update sent on 17 July 2019.
28/07/19	**Diversity and Inclusion Dashboard Update** Consider content of a commentary and how it could complement the dashboards.	Staynton Brown	-	This feedback will be incorporated into further iterations of the D&I Dashboard.

Safety, Sustainability and Human Resources Panel

Date: 4 September 2019

Item: Tram Overturning at Sandilands, Croydon on 9 November 2016 – Update

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This paper will be considered in public

1 Summary

1.1 On Wednesday 9 November 2016, a tram travelling from New Addington towards East Croydon overturned on the approach to Sandilands tram stop on a curved track which has a permanent speed restriction of 20km/h. The tram was travelling at approximately 73km/h. Of the 69 passengers on board, seven lost their lives and 62 people were injured, 19 seriously.

1.2 Saturday 9 November 2019 will be the 3rd anniversary of this tragedy. Our thoughts remain with all those affected and we will continue to do all we can to provide support. Measures to assist all those affected by the tragedy remain in place and we continue to deal with requests for support quickly and many of the claims for compensation have been resolved. The TfL Sarah Hope Line remains available to all those affected.

1.3 Since the tragedy regular reports have been made to the Safety, Sustainability and Human Resources Panel (the Panel) and to the Board:

(a) the Panel received a presentation prior to resumption of the tram service on 17 November 2016;

(b) papers updating the Panel and the Board on the activities underway and planned were provided on: 15 December 2016 (Board), 23 January 2017, 8 February 2017 (Board), 21 March 2017, 26 June 2017, 28 September 2017 and 22 November 2017;

(c) on 22 January 2018, at a special meeting of the Panel focused on Sandilands and noted two papers. Those papers reported on the Rail Accident Investigation Branch (RAIB) and TfL investigations and also on TfL's non-Operational responses to the tragedy;

(d) since January 2018 every meeting of the Panel has been provided with an update in each quarterly Health Safety and Environment Performance report, which includes as a separate appendix a table setting out the Sandilands investigations recommendations applicable to TfL and the progress made against each. The text from the current HSE Performance report is attached as Appendix 1 to this paper;

(e) a paper was also provided to the Board on 24 July 2018 dealing with the circumstances in which a TfL audit of TOL's fatigue management processes arising from a separate incident in May 2017 in Church Street, Croydon and issued in September 2017 was not provided to the external organisations investigating the Sandilands tram overturning until February and March 2018; and

(f) all of these papers and reports have been published on the our website.

1.4 The purpose of this paper is to provide a further update on the:

(a) progress against the recommendations arising from the investigations into the Tram overturning and derailment;

(b) non-operational activities which are underway and planned following the incident;

(c) support provided and response to claims brought by bereaved family members and those who were injured and otherwise affected by the tragedy, including the wider New Addington community in Croydon; and

(d) continuing support being provided to the Office of Rail and Road (ORR) and British Transport Police (BTP) investigations.

2 Recommendation

2.1 **The Panel is asked to note the paper.**

3 Progress against the recommendations arising from the investigations into the Tram overturning and derailment

3.1 As set out in the papers to the special meeting of the Panel on 22 January 2018, there are four separate investigations:

(a) RAIB, as the UK's independent railway accident investigation organisation, undertook the investigation to understand the causes of the accident and provide recommendations for industry learning;

(b) TfL commissioned an independent investigation from SNC Lavalin seeking to identify root causes and produce recommendations specifically related to the operation of the Croydon Tram system;

(c) the ORR is seeking to identify if there were any breaches of health and safety legislation; and

(d) the BTP is undertaking an investigation, which is focused on whether there was any criminal action.

3.2 The RAIB published its report on 7 December 2017. This was reported to and discussed by the Panel on 22 January 2018. An updated report dated 24 October 2018 was published by the RAIB, replacing the original report, and can be found here:

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/750889/R182017_181024_Sandilands_v2.pdf

3.3 In addition to typographic amendments and minor corrections the updated version of the report adds:

(a) a new appendix 1 containing RAIB's letter of preliminary advice on the areas of RAIB recommendations dated 21 July 2017 as sent by RAIB to all major UK Tram operators, to UKTram and copied to the ORR and

(b) an addendum discussing the TfL audit of TOL's fatigue management system (ref IA 17 780).

3.4 The SNC Lavalin report dated 10 January 2018 was published with the papers provided to the meeting of the Panel on 22 January 2018.

3.5 The ORR and BTP investigations are ongoing.

3.6 We have set out in each quarterly Health, Safety and Environment (HSE) Performance report since the meeting of the Panel on 22 January 2018 the progress which continues on each of the RAIB recommendations. The text from the current 2019 HSE Performance report (elsewhere on the agenda) is attached as Appendix 1 to this paper.

4 Summary of the progress against the recommendations

4.1 We have introduced a number of safety measures to the tram network as noted below. Some of these were started whilst we were awaiting the outcome of our own and RAIB's investigations. The findings of our own investigation, conducted by SNC Lavalin on our behalf, support those in the RAIB's report, with our recommendations focussed on London Tram, rather than the wider industry.

4.2 Set out below is a summary of the work which has been done and which continues to introduce a number of additional safety measures on the tram network and ensure that such a tragedy never happens again. We continue to work with the wider industry to implement the recommendations set out by the RAIB and to share our research findings.

4.3 In November 2017, we implemented a permanent speed reduction across the London Trams network, meaning the maximum speed trams can travel will be 70kph (previously 80kph).

4.4 Step down speed signage (to 20kph) was also installed in November 2017 at four locations, providing a graduated reduction in allowable line speed on approach to sharp curves.

4.5 Chevron signs have been installed at Sandilands and at the three other significant bends to provide an additional visual cue for drivers. The number of speed signs has been increased and additional lineside digital signage provides added speed warnings to drivers.

4.6 Tram activated speed signs have also been installed at key locations as agreed with TOL. Following feedback from drivers we will be upgrading the sign at Sandilands and this will be installed in autumn 2019.

4.7 Together with our operator 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 the enhanced visual cues for drivers.

4.8 Working with our highway experts within TfL a specification for enhanced tunnel lighting was 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. The enhanced tunnel lighting will be completed by the end of 2019.

4.9 In addition, we have adopted highways type road studs ("cats eyes") as a sleeper mounted orientation aid within the Sandilands tunnel. The studs have been deployed on the tunnel Up road only to provide differentiation between directions of travel. The studs are also configured to provide visual orientation between the individual tunnel sections. Installation was completed in May 2019.

4.10 Together with TOL we have installed an in-cab driver protection device to all trams, which has been in service since October 2017.

4.11 The Driver Protection Device (Guardian, manufactured by Seeing Machines) detects and prevents fatigue and distraction. The system uses advanced, safety-verified sensors that track eyelid closures and head movements so that when fatigue or distraction is detected an in-cab alarm is sounded and the driver's seat vibrates to alert the driver. This is the first time such a device has been used in the rail industry in the UK and has been commended by the ORR. This system has been shared and demonstrated to the UK Tram industry for possible implementation on other tram networks.

4.12 This system is designed to detect driver inattentiveness and provide an alert, but does not apply the brakes, as suggested as an option in the recommendation. The ORR has stated it recognises the safety benefits this system has brought to London Trams.

4.13 Work will continue with TOL to explore what automatic response is appropriate if a low level of driver attentiveness is detected. That will include the application of vehicle brakes. Together with TOL, we are reviewing and evaluating the outcome of the UK Trams research in the context of pending implementation of the physical prevention of over-speeding system, to determine if any further measures should be taken.

4.14 We have improved the protection that tram windows and doors provide passengers. We commissioned the manufacture and testing of several prototype windows that may provide an appropriate level of additional containment. These prototypes were assessed against the conditions likely to have been encountered during the Sandilands incident, and took into account any effect they may have on ease of access for the emergency services. After extensive research and destructive testing to investigate the most appropriate retrospective solution for the London tram fleet, an enhanced strength window film was selected and has now been installed. This is a new higher specification film that is 75 per cent thicker (from 100 microns to 175 microns). TOL supported our research and selection of the preferred solution which we have shared with the wider tram industry.

4.15 Work on developing an in-cab driver alert system for monitoring and managing tram speed, including the automatic application of emergency brakes is continuing; after a global search into appropriate proven technologies, we awarded a contract on 14 December 2018. TOL were an active stakeholder in this and have supported us in this research. This system will be set to activate at a safe margin above the posted speed limits at high risk locations. On activation the physical prevention of over-speeding system, PPOS, will bring a tram to a stop on the basis that a clear over speed violation has occurred.

4.16 London Trams network will be the first in the UK to have an automatic braking system.

4.17 Installation of the system will begin in August/September and will be in operation by the end of 2019, including a period of training and familiarisation with tram drivers ahead of it becoming fully operational.

4.18 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.

4.19 We are working to improve locally powered emergency lighting and are developing a specification for the tram fleet which will prevent unintentional interruption during an emergency

4.20 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.

4.21 Design of the new system is underway, with fleet roll out planned for later this year.

4.22 We have two types of tram on our network. The CCTV recording system on our Stadler trams has been replaced and upgraded. Replacement of the

Bombardier on-tram recording equipment and updating this to digital equipment should be completed by October 2019.

4.23 We have enhanced our procedures for reviewing and revising our tram maintenance procedures and testing documentation to take account of experience gained and modifications made since the trams were brought into service.

4.24 We have revised our processes for the reporting of safety complaints and made these more effective. We have also reviewed our processes for responding to these to ensure they remain effective.

4.25 In addition to the measures proposed by the RAIB, we are also adopting iBus technology on our Stadler trams to notify the driver of over speeding – to be known as iTram and is expected to be completed by the end of 2019.

5 Wider Industry and TfL engagement

5.1 We also continue to work with the wider tram industry on these improvements and have held two trams summits, where collectively we considered progress to date and possible further improvements. At our second summit we also shared the lessons learnt from our investigation, in addition to considering the recommendations arising from RAIB's investigation.

5.2 Within TfL, we continue to review all the recommendations from both RAIB's and our own investigation reports to identify and implement any wider learning across our organisation and via our contractors and partners. Specifically we have identified the following actions to take forward within our main operational business areas:

(a) strengthen the arrangements for monitoring and managing fatigue risk;

(b) review our risk assessment processes and the effectiveness of controls to reflect the understanding of risk from the Sandilands incident and that they are capable of identifying and correctly assessing all significant risks;

(c) embedding a 'fair culture' which balances the need for a non-punitive reporting and continuous learning environment with the need to hold persons accountable for their actions, thereby creating an atmosphere of trust;

(d) review whether the preferred glazing solution for trams is appropriate for our other transport types to improve passenger containment; and

(e) review our mechanisms for promoting and embedding organisational learning.

5.3 We were a key part of the ORR's/UK Tram industry's steering group (and its working groups) set up to establish an industry body responsible for

ensuring better cooperation on safety and standards. This steering group fulfilled its remit with the establishment of the Light Rail Safety Standards Board (LRSSB) at the beginning of February 2019.

5.4 We have formally agreed to the setting up of the LRSSB and to our allocation of the funding needed for the first three years of operation. We have agreed to its governance arrangements and potential future work plan and have responded to UKTram to confirm this.

5.5 Our Director of Rail and Sponsored Services is also one of the four Non-Executive Directors on the LRSSB. The first meeting of the LRSSB took place on 12 February 2019. We continue to see the collaborative approach fostered through this group as the best means to deliver the improvements required across the industry.

6 Better understanding of all safety risks associated with tramway operations

6.1 One of the RAIB recommendations was for UK tram operators, owners and infrastructure managers to conduct jointly a systematic review of operational risks and control measures associated with the design, maintenance and operation of tramways. We fully participated in this pan-industry review sharing how we assess and manage our risks with the team carrying out this work. From this review, as part of the tram sector we have agreed the basis of an industry wide risk model.

6.2 We are now working with the LRSSB to implement this model. Until the risk model is rolled out across the industry we continue to use our safety risk model developed jointly with TOL to inform our risk management.

6.3 As part of the development of the industry model we have agreed to provide incident and accident data to support the model. Data used in our revised risk model has been provided and TOL have also submitted five years of data in support of this.

7 Continuing support to and engagement with all those affected by the tragedy

7.1 We have worked hard to ensure that those affected by the overturning are being provided with all appropriate support and assistance. This has been through interim payments, counselling and therapeutic support as necessary. We have also provided support and counselling to staff as required.

7.2 We are working with the BTP, London Borough of Croydon, claimants' solicitors and a survivors' group to remain in contact with and offer continuing communications with those affected about the overturning and derailment, the investigations into the causes, the infrastructure and other improvements which have been made, the Coroner's Inquest and the criminal and regulatory steps which have yet to commence.

7.3 We have worked and will continue to work to support the BTP, the RAIB, the ORR and others to establish the cause or causes.

7.4 TfL's Sarah Hope Line, run by specially trained and dedicated TfL staff, remains available to all those affected to provide practical, financial and emotional help and also to make referrals for counselling and specialised support.

7.5 In addition to direct contact with those affected, a page was created on the TfL website shortly after the overturning for the purpose of providing access to information and documents and providing up to date information relevant to the incident and the various investigations into the causes of the overturning and derailment: https://tfl.gov.uk/modes/trams/croydon-tram-derailment. The page will continue to be displayed and updated for the foreseeable future.

7.6 TfL and TOL are jointly insured in relation to the overturning and derailment. We have worked together to support the insurers and claims handlers to respond to personal injury and Fatal Accident claims. We have agreed to share equally any costs arising which may not be covered by the insurance. We have sought to support bereaved families and passengers directly affected through the provision of counselling, rehabilitation, financial compensation, free transport and other support. We are also working proactively with all those affected and their legal representatives to progress civil claims quickly. We made contact with everyone injured who notified us of a claim and also with the dependents of the people who lost their lives to admit liability in respect of civil claims, to offer interim payments and other support. We are proactively staying in contact with all those affected to be available to provide continued support as and when needed.

7.7 We have proactively maintained contact with claimants and their solicitors to keep in touch over their progress with the preparation of their claims, to repeat our offers of interim payments to limit or alleviate financial hardship as far as we can and to look for ways in which we can assist those who have been affected. To date 53 claims from a total of 90 notified claims have been resolved. We have recently written to all of those claimants whose claims have not been able to be resolved to date with a proposal to ensure that they can continue to bring their claims after the statutory three year limitation period which will apply from November 2019.

7.8 In addition, we are working with the representatives of the families of those who lost their lives in the incident to agree costs for them to be represented at the Coroner's Inquest which will be held at a date yet to be fixed. We will continue to support and assist them as necessary in relation to the Inquest.

7.9 TfL has met with representatives of the London Borough of Croydon several times in the past year to discuss the impact of the overturning on the broader New Addington community and the support that may be required over coming years. In March 2018, the Mayor of London announced that TfL would provide £750,000 in support of Croydon Council's community recovery activities following the tragedy. The funds are to be provided to

support health and social services in New Addington and the surrounding community, where many of those directly or indirectly affected by the tragedy live. Croydon and local commissioning groups have proposed a range of action to help local people, including more community and social care and increases to adult and child mental health resources.

8 TfL Internal Audit Report: Management of Fatigue in Tram Operations Limited (TOL)

8.1 In response to concerns about tram driver fatigue following an incident in May 2017 recorded by a member of the public on their mobile phone on a tram in Church Street in Croydon, TfL commissioned an internal audit into the management of fatigue by TOL. We also drew it to the attention of the RAIB and ORR immediately we were made aware of it and contacted the BTP so that they could pass the information on to the Sandilands victims and the bereaved families. The report was issued on 15 September 2017.

8.2 The RAIB and ORR do not require us to automatically share all our audit reports with them but to review whether our reports might be material to their investigations and provide them as appropriate. We provided the RAIB and ORR with all material which they requested as part of their investigations but clearly, in hindsight and in the context, we should have sent them a copy of the final report at this point.

8.3 At the special meeting of the Panel on 22 January 2018, the Chair asked if the audit report had been sent to the external bodies investigating the Sandilands incident, he having previously proposed that this should be done. TfL's Director of Health and Safety said that she believed it had been sent but would confirm. Following the meeting it was discovered that the audit report had not in fact been sent to the external bodies.

8.4 Our Health and Safety department was responsible for sharing this audit report with the external bodies, but in error it was not sent as originally thought. This was clearly an oversight, which was rectified as soon as we realised that this had occurred. The Director of Health and Safety also contacted the Chair of the Panel to inform him of the error, to apologise and to confirm that the audit report had been sent.

8.5 The audit report was issued to the RAIB, ORR, BTP (on 12 February 2018) and SNC-Lavalin (on 15 March 2018). It is also published on the TfL website.

8.6 An updated RAIB report, dated 24 October 2018, was published by the RAIB, replacing the original report. The updated version of the report adds an addendum discussing the TfL audit of TOL's fatigue management system (ref IA 17 780)

8.7 We have strengthened our procedures to ensure a more robust check is made as to whether any of our audit reports could have a material impact on a live investigation, and if so, we will now automatically forward a copy

of the final report to the investigators/regulator to support their investigations.

8.8 A paper containing a report into the error was provided to the Board on 24 July 2018. The paper was published on the TfL website.

8.9 The Chair of the Panel at the time, Mr Michael Liebreich, wrote on 15 February 2019 to the Transport Commissioner expressing concerns about what happened. That correspondence, together with the Commissioner's response, has been sent by TfL and Mr Liebreich to the ORR, RAIB and BTP to maintain transparency.

8.10 On 4 July 2018 at a plenary meeting of the London Assembly a motion was agreed which called upon the Mayor to appoint an independent investigation to review why TfL failed to supply the audit report to the RAIB, the ORR and the BTP. The Mayor has since responded that a further investigation would not have any benefit, particularly bearing in mind the existence of the RAIB investigation (which included fatigue management and summarised the TfL audit in its final report), TfL's independent investigation into the Sandilands overturning, and the separate TfL fatigue report.

9 Next Steps

9.1 We will continue to work hard to ensure that those affected by the overturning are being provided with all appropriate support and assistance. This has been provided through interim payments, counselling and therapeutic support as necessary. We have also provided support and counselling to staff as required

9.2 We will continue to work with the BTP, London Borough of Croydon, claimants' solicitors and a survivors' group to remain in contact with and offer continuing communications with those affected about the overturning and derailment, the investigations into the causes, the infrastructure and other improvements which have been made, the Coroner's Inquest and the criminal and regulatory steps which have yet to commence.

9.3 We continue to engage with and report progress on the actions we are taking to address the RAIB recommendations.

9.4 We will continue to report progress against the RAIB's and our own recommendations to the Panel via the quarterly Health Safety and Environment report.

9.5 We will implement the relevant lessons learnt from both investigations more widely across our operational businesses.

9.6 We will continue to provide support to the ORR and BTP, as required, while they complete their investigations.

9.7 We will continue to work with the wider Tram industry to ensure all the RAIB's recommendations are actioned and tramway safety continues to improve across the industry.

List of appendices:

Appendix 1: Sandilands investigation recommendations applicable to TfL

List of Background Papers:

None

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Appendix 1: Sandilands investigation recommendations applicable to TfL

Recommendation	Progress to date
UK tram operators, owners and infrastructure managers should conduct a systematic review of operational risks and control measures associated with the design, maintenance and operation of tramways. [RAIB recommendation 2. Links with RAIB Recommendation 1, 10, and TfL Recommendation 5]	Complete: Together with Tram Operations Ltd (TOL) we are represented on the UK Tram Industry Sandilands Sub Committee, established to consider the RAIB findings and take action on behalf of the UK tram industry. Our (together with TOL) review of route risk assessments and our network risk model has been shared with the wider UK tram industry. The industry has reviewed all risk assessments within the industry to agree a standard approach, a standard model has been developed and verified. it is now being rolled out. In support of the model we have also agreed the arrangements to collect industry incident and injury data. National roll out for the risk model and data model In Q1 there were 19 vulnerable road users were killed or seriously injured in collisions involving buses, a 21 per cent improvement from last year. We presented an overview and findings of Risk Model work to Rail Safety and Standards Board Risk Management Forum in June 2018. The model was revised again in March 2019.
UK tram operators, owners and infrastructure managers should work together to review, develop, and install suitable measures to automatically reduce tram speeds if they approach higher risk locations at speeds which could result in derailment or overturning. [RAIB recommendation 3. Links with TfL recommendation 2]	In Progress: A contract was awarded to Engineering Support Group in December 2018. The new system will automatically bring a moving tram to a controlled stop if it were to exceed the speed limit (by a safe margin) at a designated location. It will also alert the operations control centre. The system will initially be configured to priority locations as suggested by the RAIB recommendation. It also has the flexibility to be introduced elsewhere on the tram network. We remain on target for the system to be installed and in operation by the end of 2019. (This includes a period of training and familiarisation with tram drivers ahead of it becoming fully operational.) TOL are an active stakeholder in this. The Feasibility and scoping work for this system has been shared with other tram owners and operators to assist in the development of a programme for installing similar suitable systems to their networks.

Recommendation	Progress to date
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. [RAIB recommendation 4]	In progress: Working closely with TOL, LT has procured and commissioned the 'Seeing Machine Guardian' driver protection system fleet wide. This system uses proven facial movement technology to monitor driver fatigue and distraction. The system was fully installed across the LT fleet in October 2017. An additional feature of the Guardian system is that it is programmed to alert drivers if the maximum speed goes above 70kph. TOL were closely involved in the selection and implementation of this system and played the major role in securing driver support. LT and TOL have already hosted several delegations, including UKTram and others, to demonstrate the technology in operation. While the systems does not apply the brakes automatically, the Office of Rail and Road (ORR) recognses the safety benefits the system has brought to London Trams. This system is designed to detect driver inattentiveness and provide an alert, but does not, itself, apply the brakes, as suggested as an option in the recommendation. As detailed in recommendation three, an automatic braking system has been procured and will be installed by the end of 2019 as a separate measure. Research work being undertaken by UK Trams is exploring what an appropriate automatic response would be if a low level of driver attentiveness is detected, such as the application of brakes. TfL will review this research to ensure the system in use is compatible with the outcomes
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 required by drivers on the approach to high risk locations.	Complete: We undertook a comprehensive review of tram speeds and speed signage across its network. As a result the following measures were put in place by September 2017. TOL are an active and engaged stakeholder on this initiative: 1. The maximum tram speed on the network was reduced by 10kph, from 80kph to 70kph. The effect is that the potential for coasting in high speed areas has been removed, and that continual speed management is required in these low workload areas so increasing driver alertness. 2. Additional step down speed signage was implemented in all locations where speeds reduced by more than 20kph, enhancing driver visual cueing and orientation. 3. Where speed signs are located immediately in advance of higher risk locations, e.g. a tram stop or a curve with low approach visibility, the sign has been enhanced with the addition high visibility outer border as an additional visual cue to drivers of an approaching hazard. iTram We will also implement iTram to provide audible in-cab over speed alerts. iTram is a performance monitoring tool that as well as driving safety improvements by trend analysis of tram speeds, also utilises GPS technology to provide over speed warnings to drivers at all points across the network. It is therefore an enhancement on the Guardian system which can only alert drivers if they exceed the maximum speed limit. Fitment across the fleet will be completed by December 2019

Recommendation	Progress to date
[RAIB recommendation 5. Links to TfL Recommendation 1]	Review of Visual Cueing Together with TOL we have completed a comprehensive Route Hazard Analysis. The conclusion is that the already completed installation of additional speed signage work improves driver visual cueing on the network. Conceptual designs for enhanced visual cueing in Sandilands tunnel are under TOL driver consultation. Tunnel Lighting Post the Sandilands incident we installed additional temporary lighting on the approach to the Sandilands tunnel, while our road tunnel lighting experts developed a permanent solution. The new design will adopt best practice from the automotive industry to reduce the impact of glare on driver's eyes both when entering and exiting the tunnel. Work is expected to be complete on the improved tunnel lighting by December 2019. Installation of highways type road studs ("cats eyes") as a sleeper mounted orientation aid within the Sandilands tunnel was completed in May 2019. The studs are deployed on the 'Up' road only to provide differentiation between directions of travel. They are also configured to provide visual orientation between the individual tunnel sections We are also trialling illuminated warning signs, similar to those used on roads to warn drivers their speed is above the limit. The effectiveness of these signs will be evaluated in summer 2019 and the feedback will be shared with the UK tram industry.
UK tram operators and owners should, in consultation with appropriate tram manufacturers and other European tramways, review existing research and, if necessary, undertake further research to identify means of improving the customer containment provided by tram windows and doors. [RAIB recommendation 6. Links to TfL Recommendation 8]	Complete: We commissioned the manufacture and testing of several prototype windows that could provide an appropriate level of additional containment. These prototypes were assessed against the conditions likely to have been encountered during the Sandilands incident, and taking into account any affect they may have on ease of access for the emergency services. We concluded that mainline rail crash worthiness standard GM/RT2100 is more likely to offer protection against the conditions experienced during the Sandilands event. Strengthening film on top of the existing tempered glass was selected as the immediate solution to strengthen glazing on trams. Following the extensive testing with safety experts and a new higher specification film that is 75% thicker (from 100microns to 175microns) has been fitted to all doors and windows to improve containment. We are investigating the practicalities of modifying tram doors and we will consider the recommendations made by the RAIB when designing new vehicles in the future.
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. [RAIB recommendation 7]	In progress: In conjunction with industry experts, we have formulated a Technical Specification for the retrofitting emergency lighting to its fleet. The system will be fully autonomous, and will operate independently of the trams battery system in the event of an emergency. Role out of the system is planned for autumn 2019. TOL are an active and engaged stakeholder on this initiative.

Recommendation	Progress to date
UK tram operators and owners should review options for enabling the rapid evacuation of a tram which is lying on its side after an accident. [RAIB recommendation 8]	In progress: We continue to work with tram operators and tram manufacturers to identify and evaluate options to achieve this objective.
TOL and LT should commission an independent review of its process for assessing risk associated with the operation of trams. [RAIB recommendation 10. Links with RAIB recommendation 2]	Complete: The network risk model and route risk assessments have been reviewed and updated. They have been shared with the wider UK tram industry and we also presented an overview and findings of Risk Model work to Rail Safety and Standards Board Risk Management Forum in June 2018. Work has also been completed on our tram crossing risk assessments for Croydon town centre. A joint management process for the embedment of the models has been developed. They remain under regular review. The most recent review of the LT Risk Model was completed in March 2019. The industry is reviewing all risk assessments within the industry to agree a standard approach. The LT/TOL risk assessments will be further reviewed and revised in line with this approach.
TOL should review and, where necessary, improve the management of fatigue risk affecting its tram drivers with reference to the ORR's good practice guidance. [RAIB recommendation 11]	In progress: TOL are implementing a safety improvement plan designed to address the intent of this recommendation through their own internal safety governance arrangements.
TOL should commission an external organisation to review, the way that it learns from operational experience. [RAIB recommendation 12]	Complete: TOL have implemented a 'Just Culture' Programme designed to address the intent of this recommendation through their own internal safety governance arrangements.
TOL and LT should review and improve the process for managing public and employee comments that indicate a possible safety risk. [RAIB recommendation 13]	Complete: We have reviewed our customer complaints procedure and how employees report issues to us and implemented improvements to ensure that any safety issue raised is dealt with efficiently and thoroughly across the TfL network.
TOL and LT should review and improve their processes for inspecting and maintaining on-tram CCTV equipment to greatly reduce the likelihood of recorded images being unavailable for accident and incident investigation. This recommendation may apply to other UK tram operators. [RAIB recommendation 14]	Complete: All LT Bombardier fleet has been fitted with new CCTV image recorders. CCTV health checkers which actively monitor the status of recording units and identify faults. The CCTV recording equipment on all Bombardier trams (type involved in Sandilands) was replaced and upgraded to digital shortly after the overturning. The equipment on Stadler trams, which make up the remainder of the fleet, had adequate functionality. Further work to upgrade CCTV on the wider fleet will be completed by May 2019.

Recommendation	Progress to date
TOL and LT should review and revise where required existing tram maintenance and testing documentation to take account of experienced gained, and modifications made, since the trams were brought into operational service. [RAIB recommendation 15]	In progress: LT has undertaken a comprehensive review of its written standards, maintenance processes and identified quality deficiencies. LT has appointed an independent entity to author new written standards, maintenance processes and forms addressing all quality gaps. This process will be in two phases. Sixteen critically prioritised standards and associated documents have been delivered in the first phase. The remaining standards and processes will be addressed through our routine arrangements for the maintenance of the management system.
Review available driver cues in relation to braking points on approaching a curved section of the tramway. [TfL recommendation 1. Links to RAIB recommendation 5]	Complete: Overall network top speed has been reduced from 80kph to 70kph. Additional 70kph signs have been provided to aid driver awareness of the permitted maximum speed. A design and signal sighting exercise has been concluded and the provision of additional step down speed signage to aid driver speed awareness and visual cueing is complete. Additional visibility signs have also been provided, which will heighten driver speed awareness in high risk areas.
Review available driver cues in relation to braking points on approaching a curved section of the tramway. [TfL recommendation 1. Links to RAIB recommendation 5]	Complete: Overall network top speed has been reduced from 80kph to 70kph. Additional 70kph signs have been provided to aid driver awareness of the permitted maximum speed. A design and signal sighting exercise has been concluded and the provision of additional step down speed signage to aid driver speed awareness and visual cueing is complete. Additional visibility signs have also been provided, which will heighten driver speed awareness in high risk areas.
Review of arrangements for the monitoring and management of speeding. [TfL recommendation 2. Links to RAIB recommendation 3]	LT has commissioned the installation and commissioning of the 'iTram' system, which will provide driver over-speed alerts network wide. iTram will also provide oncoming hazard awareness to drivers of high risk areas. The system has been installed on all 22 Bombardier trams and the roll-out on Stadler trams began in April 2019.
Review of traction brake controller (TBC) driver's safety device design. [TfL recommendation 3]	Complete: LT has procured and commissioned the 'Seeing Machine Guardian' driver protection system fleet wide. This system provides proven driver fatigue and distraction management via facial recognition technology. It was fully installed across the London Trams fleet in October 2017. ORR recognises the safety benefits that the system has brought to London Trams.

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Safety, Sustainability and Human Resources Panel

Date: **4 September 2019**

Item: **Quarterly Health, Safety and Environment Performance Report**

This paper will be considered in public

1 Purpose

1.1 This report provides an overview of the health, safety and environment (HSE) performance for London Underground (LU), TfL Rail, Surface Transport (including London Rail), Major Projects and Crossrail.

1.2 Generally, this report covers 1 April – 22 June 2019 inclusive, referred to as Quarter 1.

2 Recommendation

2.1 The Panel is asked to note the report.

List of appendices to this report:

Appendix 1: Health, Safety and Environmental Performance – Quarter 1 2019/20

List of Background Papers:

None

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Transport for London Health, safety and environment report

Quarter 1 (1 April 2019 - 22 June 2019)

MAYOR OF LONDON

TRANSPORT FOR LONDON
EVERY JOURNEY MATTERS

About Transport for London (TfL)

Part of the Greater London Authority family led by Mayor of London Khan, we are the integrated transport authority responsible for delivering the Mayor's aims for transport.

We have a key role in shaping what life is like in London, helping to realise the Mayor's vision for a 'City for All Londoners'. We are committed to creating a fairer, greener, healthier and more prosperous city. The Mayor's Transport Strategy sets a target for 80% of all journeys to be made on foot, by cycle or using public transport by 2041. To make this a reality, we prioritise health and the quality of people's experience in everything we do.

We manage the city's red route strategic roads and, through collaboration with the London boroughs, can help shape the character of all London's streets. These are the places where Londoners travel, work, shop and socialise. Making them places for people to walk, cycle and spend time will reduce car dependency and improve air quality, revitalise town centres, boost businesses and connect communities.

We run most of London's public transport services, including the London Underground (LU), London Buses, the DLR, London Overground (LO), TfL Rail, London Trams, London River Services (LRS), London Dial-a-Ride, Victoria Coach Station (VCS), Santander Cycles and the Emirates Air Line. The quality and accessibility of these services is fundamental to Londoners' quality of life. By improving and expanding public transport, we can make people's lives easier and increase the appeal of sustainable travel over private car use.

We are moving ahead with many of London's most significant infrastructure projects, using transport to unlock growth. We are working with partners on major projects like Crossrail 2 and the Bakerloo line extension that will deliver the new homes and jobs London and the UK need. We are in the final phases of completing the Elizabeth line which, when it opens, will add 10% to London's rail capacity.

Supporting the delivery of high-density, mixed-use developments that are planned around active and sustainable travel will ensure that London's growth is good growth. We also use our own land to provide thousands of new affordable homes and our own supply chain creates tens of thousands of jobs and apprenticeships across the country.

We are committed to being an employer that is fully representative of the community we serve, where everyone can realise their potential. Our aim is to be a fully inclusive employer, valuing and celebrating the diversity of our workforce to improve services for all Londoners.

We are constantly working to improve the city for everyone. This means freezing TfL fares so everyone can afford to use public transport, using data and technology to make services intuitive and easy to use, and doing all we can to make streets and transport services accessible to all. We reinvest every penny of our income to continually improve transport networks for the people who use them every day.

None of this would be possible without the support of boroughs, communities and other partners who we work with to improve our services. We all need to pull together to deliver the Mayor's Transport Strategy; by doing so we can create a better city as London grows.

Contents

Introduction

Performance in the first quarter of the year was mixed. Unfortunately there were two customer fatalities, one on the London Underground network, arising from trespass, the other on the bus network, arising from a fall while boarding a bus. The latest provisional road collision figures (January-March 2019) indicate that 30 people were killed and 882 seriously injured on London's roads and we remain behind the trajectory needed to meet the Mayor's Vision Zero target of a 65 per cent reduction by 2022. Forty-seven people were killed or seriously injured in collisions involving a London bus. However, we are ahead of the trajectory required to meet the Vision Zero target of a 70 percent reduction in the number of people killed or seriously injured involving a London bus by 2022.

Our work to deliver Vision Zero continues:

- We began consultation on a further five Safer Junction Schemes
- Over 800 buses have now been fitted with intelligent speed assistance to improve compliance with speed limits
- The use of new technology, equipment and management practices by our bus operators continues to be supported through the second tranche of our Bus Safety Innovation Challenge
- We prepared for Vision Zero week; marking one year since the launch of our Vision Zero Action Plan and launching the 'Know My Name' campaign and Vision Zero partner badge.

Our scorecard for 2019-20 drives a focus on the elimination of death and serious injury from our public transport and we have introduced a more consistent definition of serious injury across our road and public transport networks. While the total customer injuries and total workforce injuries on our public transport networks have both improved compared with the same quarter last year, we have not met our target for reducing the number of people killed or seriously injured. In light of the new definition, we are undertaking a data cleansing exercise to ensure that serious injuries are being correctly classified.

During the quarter:

- Customer injuries on LU increased by 20 per cent compared with the same quarter last year. Our new Platform Train Interface Excellence programme, joins the existing Escalator and Stairs Excellence programmes to address this
- There were 28 per cent fewer injuries to bus customers than in the same quarter last year. Improvements to our performance information has been helping bus operators target their improvement activities; as we progressively roll out the Bus Safety Standard measures
- There were 12 per cent fewer workforce injuries compared to the same quarter last year, driven by a five per cent fewer injuries to our direct employees and a 23 per cent fewer injuries to our suppliers. Partnership working with our construction suppliers through our Zero Harm forum is delivering improvements.

This quarter we extended the use of the iTram system to our Stadler tram fleet to provide driver over-speed alerts and completed the installation of 'cats' eyes' in the Sandilands tunnel to help tram drivers differentiate direction of travel. We are also on track to deliver the Rail Accident Investigation Branch (RAIB) recommendations following the over-turning of a tram at Sandilands Junction in 2016.

This year we are presenting more detailed environmental performance in this report. This is in line with GLA group key performance indicators from the London Environment Strategy 'leading by example' chapter.

Gareth Powell
Managing Director
Surface Transport

Vernon Everitt
Managing Director
London Underground

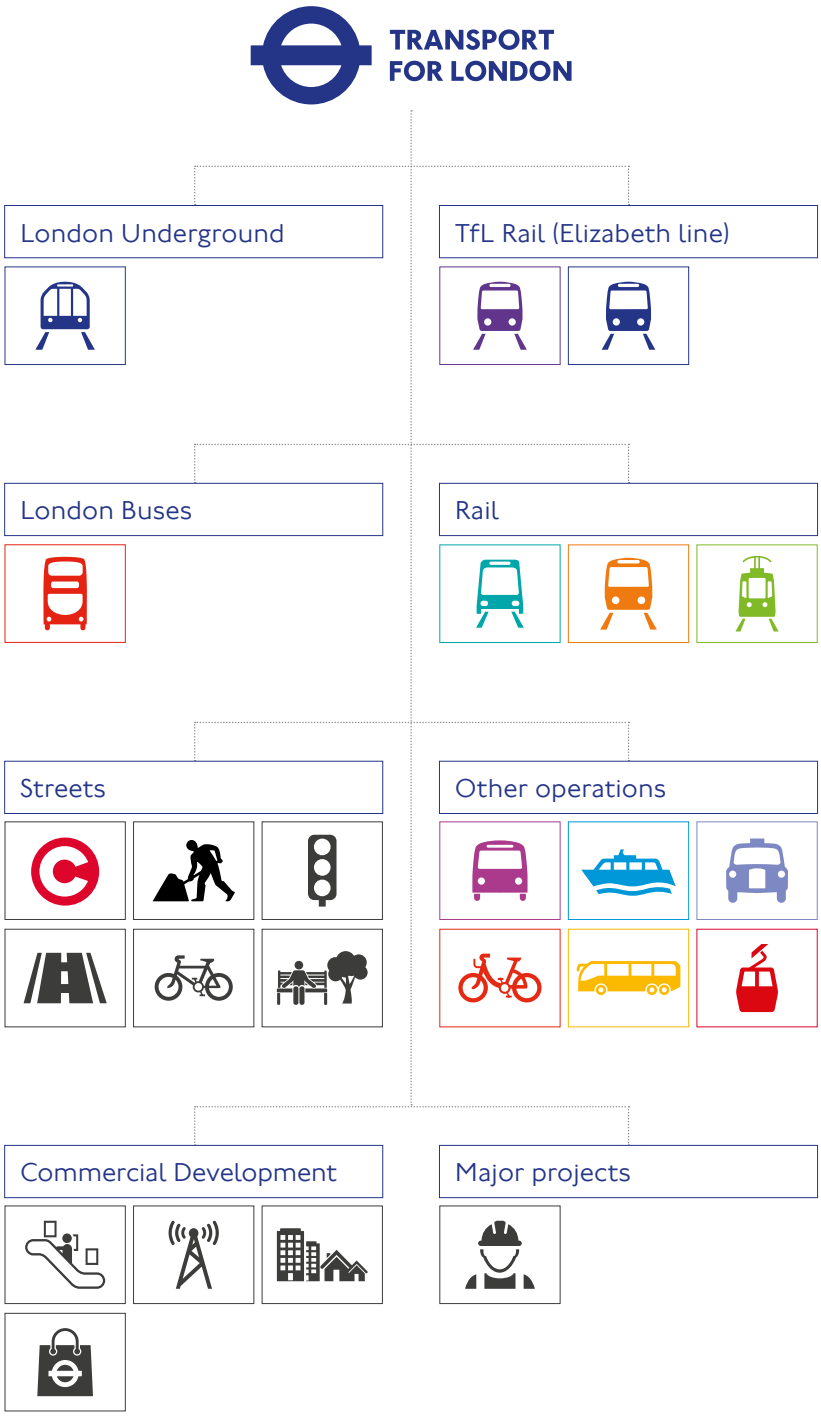
Stuart Harvey
Director
Major Projects

Jill Collis
Director
Heath, Safety and Environment

Business at a glance

Keeping London moving, working and growing to make life in our city better

How we report on our business



Facts and figures*

945 Trains on the TfL network

580km TfL-operated highways

720km TfL-operated Rail and London Underground routes

9,330 Buses on the TfL network

6,365 Traffic signals operated by TfL

* Based on full year 2018/19

Mayor's Transport strategy themes in this report

Our role is to deliver the Mayor's Transport Strategy in partnership with London's boroughs, businesses, local communities, consumer organisations and many others. The ambitious plan will increase the attractiveness of public transport and make cycling and walking easier and more convenient options.

We are providing more trains on our busiest services, and investing in upgrades and step-free access schemes. We are making local streets healthier and more pleasant places. Listening to, and acting on, the suggestions of our customers enables us to make walking, cycling and public transport the first choice for the vast majority of trips. And we will continue to improve services to unlock the new jobs and housing our city needs.

This report looks at our performance in relation to the following themes from the Mayor's Transport Strategy:

Healthy Streets and healthy people

Scorecard measures
We use a scorecard to measure our performance against the Mayor's Transport Strategy. In this report, the scorecard measures are marked like this.

Performance summary

Scorecard

Measures		Quarter 4	
Outcome	Measure	Actuals	Target
London's transport system will be safe and secure	Reduction in people killed or seriously injured on the roads from 2005-09 baseline	40.2% (51 fewer people than YTD 2018)	41.4% (81 fewer people than YTD 2018)
	Reduction in people killed or seriously injured involving buses from 2005-09 baseline	63.1% (9 fewer people than YTD 2018)	57.4% (no reduction against YTD 2018)
London's streets will be clean and green	Number of London buses that are Euro VI compliant	7400	7400
London's streets will be used more efficiently and have less traffic	Traffic signal changes to support healthy streets (person hours per day)	3730	3500
More people will travel actively	Healthy streets check for designers (average % uplift)	15%	10%
Public transport will be accessible to all	Reduction in customer and workforce killed and seriously injured (compared to 2018/19)	69 more people killed or seriously injured (21% increase)	16 fewer people killed or seriously injured (2.4% reduction)

A recent review of the data has identified that we have overestimated the number of people seriously injured. We are currently completing a data cleansing exercise in line with the correct definitions, to confirm the level of overestimation. We will then back cast the data. This may have implications on our target for reducing the number of people killed or seriously injured. The number of seriously injured people over reported is in the range of 60 to 90 per cent.

Although we have had fewer people seriously injured on our transport network the main areas of concern remain unchanged and we will continue to implement our improvements plans in these areas.

Performance summary

Scorecard

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Outcome	Measure	Actuals	Target
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	Reduction in customer and workforce killed and seriously injured (compared to 2018/19)	69 more people killed or seriously injured (21% increase)	16 fewer people killed or seriously injured (2.4% reduction)
London's streets will be clean and green	Number of London buses that are Euro VI compliant	7400	7400
More people will travel actively	Healthy streets check for designers (average % uplift)	15%	10%

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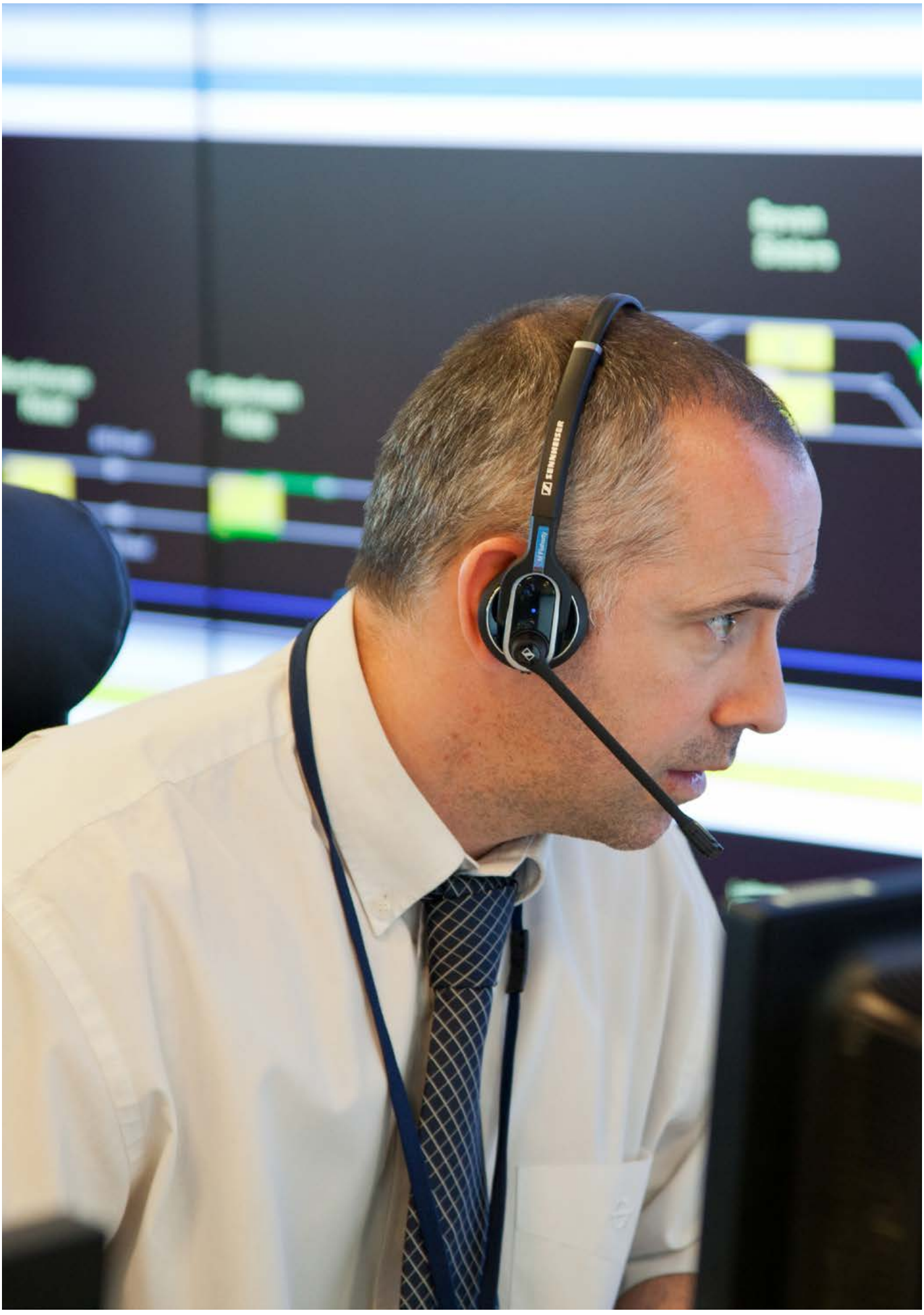
Although we have had fewer people seriously injured on our transport network the main areas of concern remain unchanged and we will continue to implement our improvements plans in these areas.



Significant incidents

Significant incidents are incidents that result in:

- A fatality, or
- Three or more people needing hospital treatment, or
- A loss of more than £1m.

This quarter

There were 27 significant incidents across London's road and public transport networks this quarter, 21 of which were fatalities:

- On London Underground, a trespasser was fatally injured after being struck by a train at Theydon Bois
- Seventeen people were killed on London's roads (provisional data for the period covered in the report, subject to change):

Pedestrians	9
Motorcyclists	6
Car drivers	1
Medical related fatality on London bus	1

- There were three fatalities relating to London Buses, of which one was a passenger falling onto the pavement while boarding a bus, and two others involving a collision with a motorbike. There were no incidents of people walking being fatally injured in collisions with London buses.

Other significant incidents arising from our public transport activities are as follows:

- Fifteen passengers were injured when a bus driver applied the brake to avoid a road traffic collision (RTC)
- Three passengers, the driver of a car and two occupants were injured following a road traffic collision
- Four passengers were injured when a bus collided with a car on route 279
- Two passengers, a bus driver and a pedestrian were injured when a bus collided with railings
- A head-on collision between a bus and a private hire vehicle resulted in 14 passengers being injured, two of whom were taken to the hospital
- A route 170 bus collided with a route 337 bus, resulting in one bus driver and six passengers injured.

London Bridge inquests

The inquests arising from the eight deaths in the London Bridge and Borough Market terror attack on 3 June 2017 took place between 7 May and 28 June 2019. TfL was an interested person in the inquests for two of the victims, Christine Archibald and Xavier Thomas, who were struck and killed by the van that was driven over London Bridge by the attackers. TfL gave evidence at the inquests about physical protective security measures on London Bridge and the removal of the pedestrian guardrails in 2010, as well as evidence about the employment of one of the attackers as a London Underground Customer Services Assistant. The City of London Corporation, which owns the physical structure of the bridge, also gave evidence about protective security measures. The Coroner concluded that all of the victims were unlawfully killed. In relation to the deaths of Christine Archibald and Xavier Thomas, the Coroner concluded there was no form of physical protective security on London Bridge although it was vulnerable to a terrorist attack using a vehicle as a weapon.

There were weaknesses in systems for assessing the need for such measures on the bridge and implementing them promptly, and without such weaknesses, suitable hostile vehicle mitigation measures may have been present. The Coroner has invited submissions from interested persons as to whether a prevention of future deaths report should be made and the points that should be included in such a report. Responses to those submissions are also invited following which the Coroner will reach his views on whether a report is made and its contents. It is expected that any such report will be issued later this year.

Rail Accident Investigation Branch (RAIB) investigations

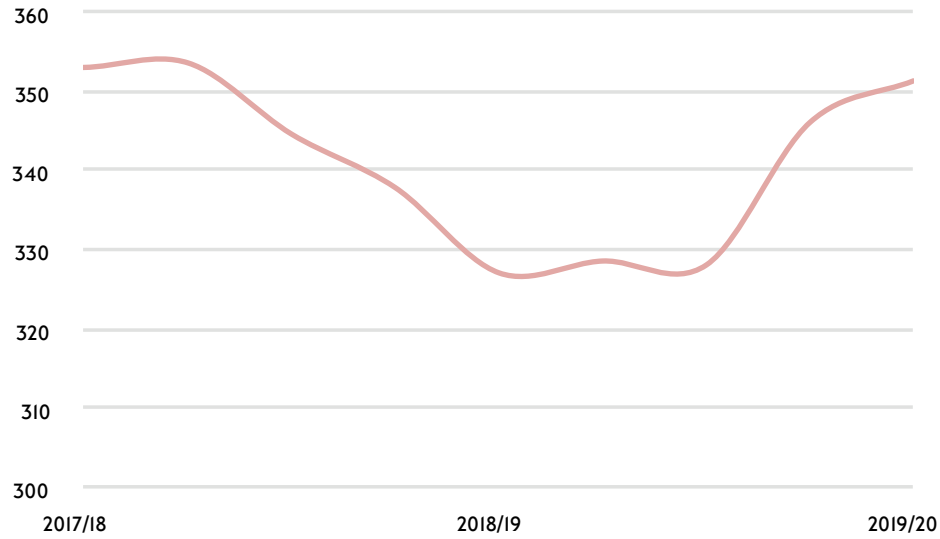
The RAIB issued their draft report into the incident in September 2018 of a London Underground Jubilee line train travelling between Finchley Road and West Hampstead stations with ten sets of doors open. No-one fell out of the train and nobody was injured. The report, which is now final made four recommendations addressed to London Underground. These include improvements to door control systems on Jubilee line trains; better training to help train operators respond correctly when sudden increases in workload occur while operating trains in automatic mode; raising train operator awareness of the adverse effects on safety from insufficient sleep and inappropriate eating patterns; and improved management of train faults. Programmes of work are underway to address these recommendations.

London's transport system will be safe and secure

London's transport system will be safe

People killed or seriously injured*

Moving annual average



* Injuries to members of the public who are not bus customers are included in the Killed or Seriously Injured (KSI) figures within the streets section.

Across our public transport network a total 313 customers were killed or seriously injured on our public transport network, an increase of seven per cent when compared to Q1 2018/19.

Provisional data indicates 30 people have been killed and 882 people seriously injured on London roads from January to March 2019.

Killed and seriously injured: definition and data sources

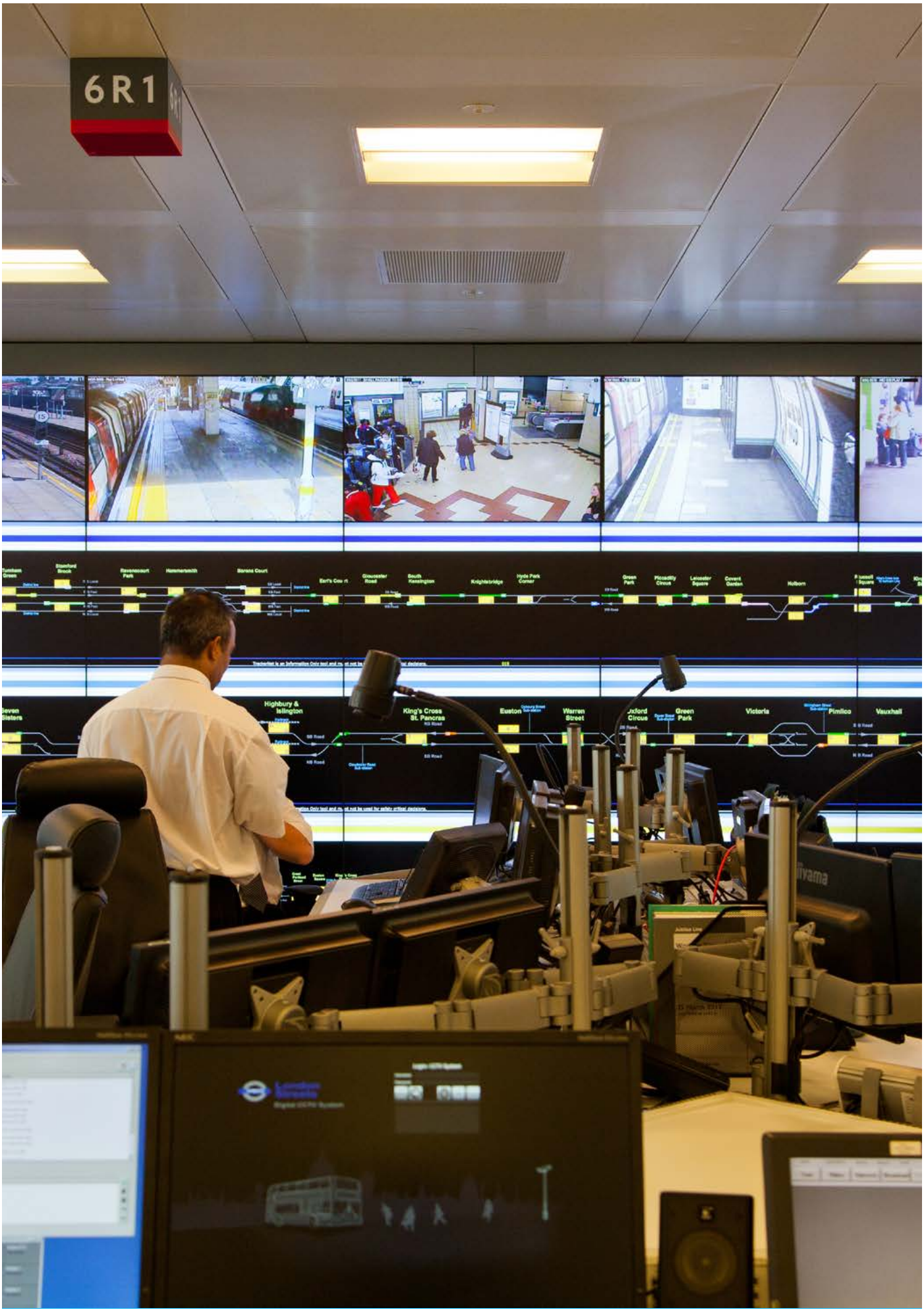
As part our ongoing arrangements to improve data quality and embed a consistent approach to the classification of injuries across all modes of transport, we have adopted a consistent measure of Killed and Seriously Injured, with the definition of serious injury derived from the relevant regulatory frameworks for the environment.

A recent review of the data has identified that we have overestimated the number of people seriously injured. We are currently completing a data cleansing exercise in line with the correct definitions, to confirm the level of overestimation. We will then back cast the data. This may have implications on our target for reducing the number of people killed or seriously injured. The number of seriously injured people over reported is in the range of 60 to 90 per cent.

Although we have had fewer people seriously injured on our transport network the main areas of concern remain unchanged and we will continue to implement our improvement plans in these areas.

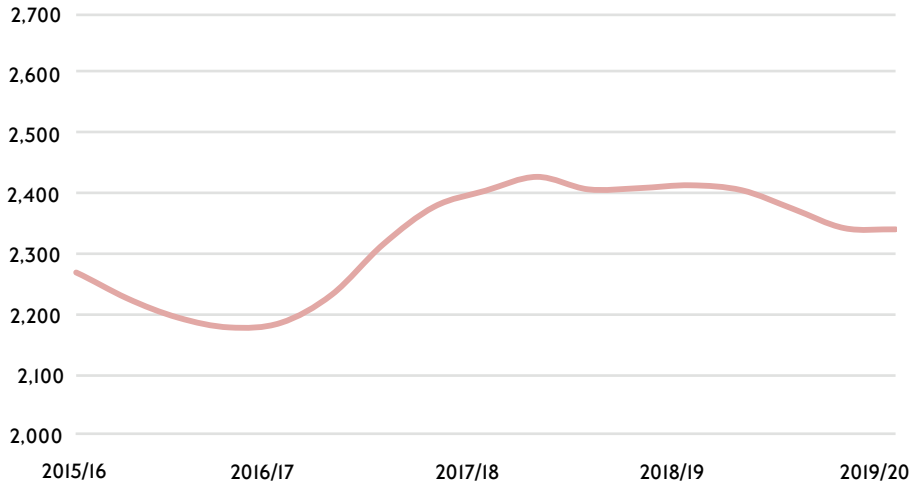
In this report we use police-recorded data when reporting customers killed and seriously injured on our streets and in collisions with our buses. This data is reported in calendar months and years, rather than four-weekly periods as elsewhere in the report. This is noted in the relevant sections.

Where figures are combined, as in the graph above, we have aligned all reporting to the financial year.


6R1
Stamford Brook
Ravenscourt Park
Hammersmith
Barons Court
Earl's Court
Gloucester Road
South Kensington
Knightsbridge
Hyde Park Corner
Green Park
Piccadilly Circus
Leicester Square
Covent Garden
Holborn
Highbury & Islington
King's Cross St. Pancras
Euston
Warren Street
Oxford Circus
Green Park
Victoria
Pimlico
Vauxhall

Customer injuries

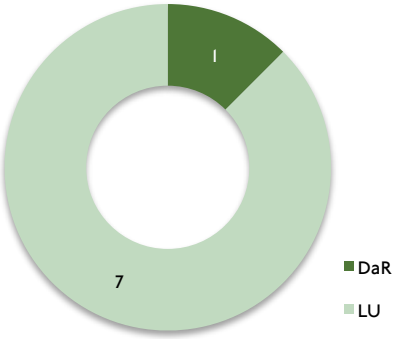
Moving annual average



During QI there were a total of 2,068 customers injuries across our public transport network, which is an eight per cent improvement on the same quarter last year.

This was largely due to a reduction of 348 injuries (28 per cent) on Buses when compared with QI last year. Unfortunately LU has seen an increase of 169 injuries (20 per cent) compared with QI last year.

Provisional figures for QI 2019 indicates there were 6,868 injuries on London roads. This is an improvement on the number of injuries (7,098) in the same quarter last year of 3.3 per cent.



RIDDOR Reportable Incidents

There were eight customer injuries that required reporting to our regulators this quarter. This represents a reduction of six incidents on last year.

One fatal incident occurred at Theydon Bois where a trespasser was struck by a train.

There were six further injuries relating to LU, four were a result of falls and two related to boarding / alighting trains. All incidents required the injured party to attend hospital for treatment.

Dial a Ride (DaR) reported one RIDDOR incident, due to a passenger sustaining a large cut to their shin whilst boarding.

3.0

Number of injuries per million passenger journeys on the Tube network (9.6% ▲ against QI 2018/19)

1.8

Number of injuries per million passenger journeys on the bus network this quarter* (23.9% ▼ against QI 2018/19)

1.1

Number of injuries per million passenger journeys within our rail operations this quarter (0.5% ▲ against QI 2018/19)

1.2

Number of injuries per million passenger journeys within our other operations this quarter (74.5% ▼ against QI 2017/18)

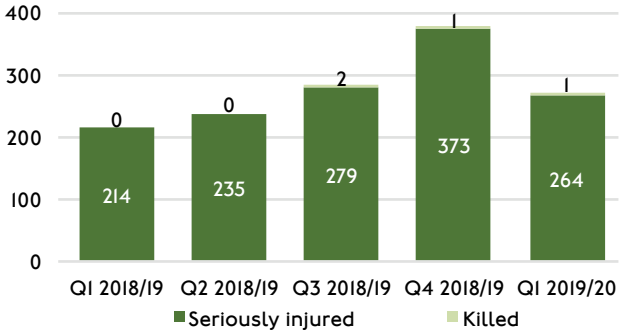
* Injuries to members of the public who are not bus customers are included in the Killed or Seriously Injured (KSI) figures within the streets section.


Way out

Underground

Customers killed or seriously injured

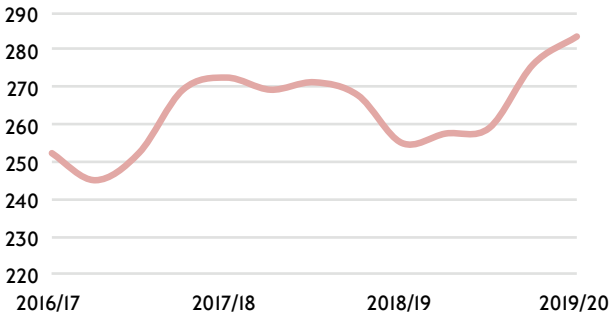
Past five quarters*



*the above figures overestimate the number of people seriously injured.

In Q1 there was one fatal incident on LU infrastructure where a trespasser was struck by a train at Theydon Bois. 264 customers were also seriously injured. This is an increase of 51 people killed or seriously injured compared to Q1 2018/19.

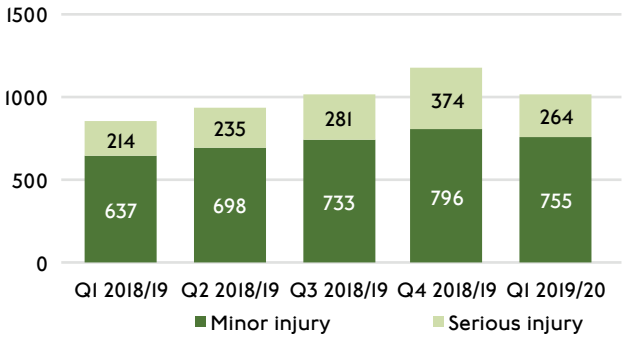
Moving annual average



This accounts for 26 per cent of all injuries on the LU network. The biggest contributing cause of serious injury remains slips, trips and falls, which account for 87 per cent.

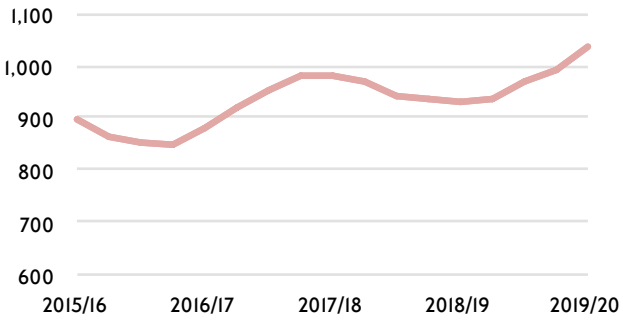
Customer injuries

Past five quarters*



*the above figures overestimate the number of people seriously injured.

Moving annual average



Top causes of injury (%)

Slips, trips and falls	77
Machinery / Equipment / Powered Tools	13
Assault	8
All other causes	1

1,020

Number of injuries on the LU network this quarter (20% ▲ against Q1 2018/19)

In Q1, LU recorded a total of 1,020 customer injuries, which equates to 47 per cent of all customer injuries sustained across TfL modes. This is an increase of 169 injuries (20 per cent) compared to Q1 last year.

Slips, trips and falls cause 77 per cent of all customer injuries. The highest number are on escalators with 398 injuries (50 per cent), followed by stairs (185 injuries).

This quarter, 265 (26 per cent) of LU customer injuries were categorised as killed or seriously injured, an increase of 51 when compared to Q1 2018/19.

The moving annual average has continued to increase in Q1 2019/20 and currently stands at 1,014, which is an increase 82 on the same quarter last year.

Did we deliver our planned improvements?

To reduce injuries on escalators and stairs

- Continue Escalator Excellence to ensure standards are maintained
  Escalator Excellence remains in place at all LU locations with escalators. This includes an ongoing programme of monitoring to ensure standards are being maintained; with a particular focus on the stations with the highest levels of incident
- Roll out Stairs Excellence at all remaining stations
  Stair Excellence work has continued and we have rolled it out at 36 stations. We will cover all the remaining stations in phases by the end of 2019/20. This approach enables us to ensure that the approach is working effectively and use lessons learned to inform the next phases.

  We are reviewing the safety benefits delivered by our Escalator and Stair Excellence programmes and will report progress in future reports
- Trial formats for safety posters to define best practice
  We reviewed customer safety posters, signage and announcements at London Bridge and Waterloo stations to define what 'good looks like'.

To reduce injuries during boarding and alighting

- Introduce PTI Excellence at top 10 stations for PTI incidents and a communications plan for 2019/20
  The PTI project continues to keep our focus on high risk incidents and key locations across the network. PTI awareness days focus on customer behaviour and good customer communication. PTI Excellence was launched and will be developed further in Q2. This builds on activities at 20 stations during 2018/19 which delivered a 23 per cent reduction in PTI injuries at those locations
- Platform camera improvement project: complete onsite improvements at a further two platforms
  We have continued delivery of our platform camera improvements project on the Central line at Bank platforms 5 and 6 and Shepherd's Bush platform 1
- Mind the gap
  A device that extends and reduces the gap between the train and the platform edge is being developed and trialled. It is called an 'active gap filler' and aims to fill the gap between a train and a platform which will reduce the likelihood of a customer falling down the gap. A prototype has been developed and is currently being tested
- Installation of under platform flashing blue lights at Baker Street platforms 1 & 2
  Following the trial of blue flashing lights to alert customers to the gap between the train and the platform; specialist electronic design resource is being sourced to undertake the detailed design. Installation will start at platform 2 at Farringdon and platforms 1 and 2 at Baker Street in March 2020.

  We also completed the trial of announcements after 8pm at Baker Street, including associated noise monitoring. We have reviewed the findings in conjunction with Westminster City Council and have agreed to extend the trial.

Our plans for next quarter

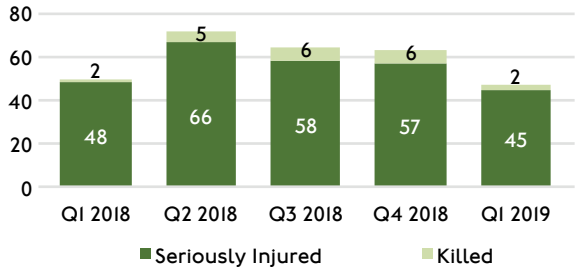
Launch a new customer safety campaign focused on keeping our customers safe when they are travelling under the influence of alcohol
Hold a senior level review of our approach to fire safety
Test the 'active gap filler' prototype
And continue our current safety programmes: • Improving safety at the platform-train interface by holding a PTI awareness day, launching a PTI safety film • Escalator Excellence to ensure standards are maintained • Define 'best practice' for customer safety at next top 8 stations for incidents • PTI Excellence at next top stations for PTI incidents


TOWER TRANSIT

Buses

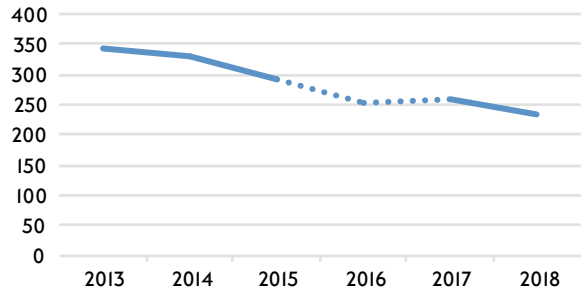
People killed or seriously injured

Past five quarters*



* Data presented on this page is for personal injury road traffic collisions occurring on the public highway, and reported to the police, in accordance with the STATS 19 national reporting system.

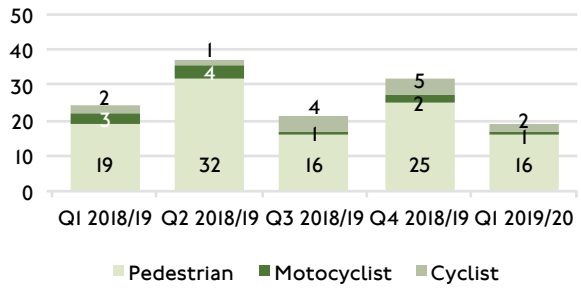
Annual totals**



Figures for 2018 show that 248 people were killed or seriously injured in collisions involving a London bus. This is a 60.1 per cent reduction from the 2005-09 baseline and ahead of the 2018 target needed to meet the Mayor's Vision Zero target of a 70 per cent reduction in the number of people killed or seriously injured in collisions involving a London bus by 2022. Provisional figures show that 47 people were killed or seriously injured in collisions involving a London bus during Q1 of 2019. This compares to 48 people killed or seriously injured in collisions involving a London bus during Q1 of 2018.

**Figures from the end of 2016 have been reported using a new system. The dotted line in the graph for calendar years 2013-16 denotes back-estimated figures following analysis undertaken with the Transport Research Laboratory to indicate how many collisions would have been reported under this system in previous years.

Past five quarters - vulnerable road users

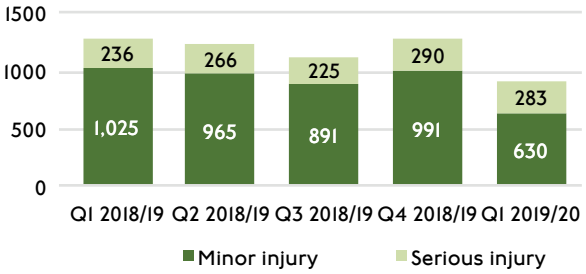


In Q1, 19 vulnerable road users were killed or seriously injured in collisions involving buses, a 21 per cent improvement from last year.

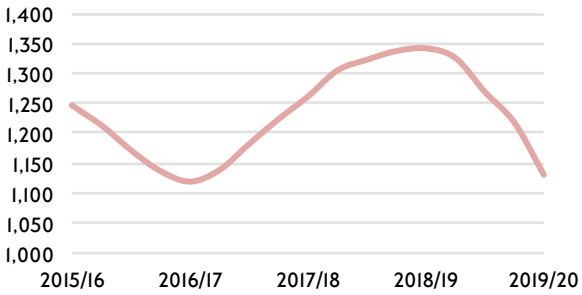
People walking continue to make up the largest proportion of those killed or seriously injured, accounting for 84 per cent. Incidents involving people riding motorcycles improved on last year but there has been no change in the number of people cycling who were killed or seriously injured.

Customer injuries**

Past five quarters*



Moving annual average



* Q4 is longer than quarters 1 to 3 (16 weeks instead of 12 weeks).

** Data presented on this page is for all personal injury events reported by or to TfL.

Top causes of injury (%)

Slips, trips and falls	57
Struck by / against object	12
Collision	7
Cut or abrasion	5

913

Number of injuries on the bus network this quarter (28% ▼ against Q1 2018/19)

London's buses have reported 348 (28 per cent) fewer injuries when compared to the same quarter last year. As well as a reduction in injuries, there has also been a reduction of five per cent in passenger journeys, from 530m down to 504m. Based on the figures for this quarter, there were 1.8 injuries per million journeys.

Slips, trips and falls continue to be the main cause of injury on London buses with 57 per cent (520 injuries).

* As part our ongoing arrangements to improve data quality and embed a consistent approach to the classification of injuries across all modes of transport, we have adopted a consistent measure of Killed and Seriously Injured, with the definition of serious injury derived from the relevant regulatory frameworks for the environment. We are completing a data cleansing exercise in line with these definitions, which will result in amendments to previously published data.

Did we deliver our planned improvements?

- Bus driver safety "Destination Zero" training to be launched
  Bus driver safety "Destination Zero" training was launched in May. All bus operators have engaged with the training programme, which is being run locally at the operator sites. Feedback has been largely positive, especially about the virtual reality training equipment which allows drivers to visualise real hazards on the road and discuss how best to avoid them
- Award of the new tranche of Bus Safety Innovation Challenge projects to bus operators
  The awards made will be published in July
- Commence development of the 'Urban Bus Sound'
  The "Urban Bus Sound" project is underway, this is part of the Acoustic Vehicle Alerting System for quiet running vehicles (hybrid and electric)
- Identification of the correct placement of Blind Spot Mirrors
  The work to identify the correct positioning of the blind spot mirrors was completed in QI, Roll out of the new mirrors will take place over the next 9 months
- The total number of buses enabled with Intelligent Speed Assistance (ISA) technology will reach over 800
  At the end of QI a total of 808 buses were fitted with ISA technology.

Other highlights

- An incident prevention day took place in Stratford during QI. This was led by Tower Transit, but attended by both TfL and the safety management for all operators working in and around the bus / Tube station and shopping centres. In addition, other operators joined the day to provide support and to learn how we run a successful prevention day. No incidents occurred during the day of the visit, but more importantly, lessons were taken away regarding traffic light timing sequences and how to improve driver awareness of potential behaviour of people walking
- Abellio ran a safety campaign to guard against one-handed steering by drivers. This is a frequent issue with driving safely; the ability to control the bus in all situations is compromised by using one hand alone. Abellio's Grand Prix X-Box game tested drivers to drive a Formula I track one-handed, which proved to be impossible and shared an important lesson about appropriate vehicle controls
- Abellio is also rolling out Mobileye technology across its entire fleet of buses, following the success of the trial in 2018. This equipment brings the drivers' attention to close following, late braking, lane departure and proximity. There was a 25 per cent reductions in collisions and injuries over the trail period. All of Abellio's fleet should be installed with the Mobileye technology by end of Q2

- Arriva has run a successful risk awareness video specifically aimed at drivers in relation to monitoring their blind spots and extra caution in use of wing mirrors. This video has been run at each depot throughout Q1 and they have received encouraging feedback from the drivers, and are monitoring the results of the training throughout Q2
- Go Ahead, RATP, Abellio and Stagecoach are testing TfL's new Speed Compliance Tool which is currently in beta phase. This tool should be available by Q3 2019/20 and can give operators information on hot spot areas in London where excessive speeding is commonplace. They will be able to narrow this down to road locations, bus types and even individual drivers
- Go Ahead has also introduced a new Pre-Service Check video for training and reminding drivers about the optimum method for carrying out the compulsory first-use check on their vehicle
- RATP successfully converted its recent cyclist awareness project into a Certificate of Professional Competence (CPC) recognised training course, so that this can go towards any driver's annual training requirement. This training not only allows them a timely reminder of the need for caution around this ever-growing hobby / commuting tool, but also gives them first hand experience on the road, as they cycle around on the roads themselves
- Both Stagecoach and Arriva have already started using the brand of Vision Zero to train drivers, specifically in relation to take all possible care around people walking, cycling and riding motorcycles.

Our plans for next quarter

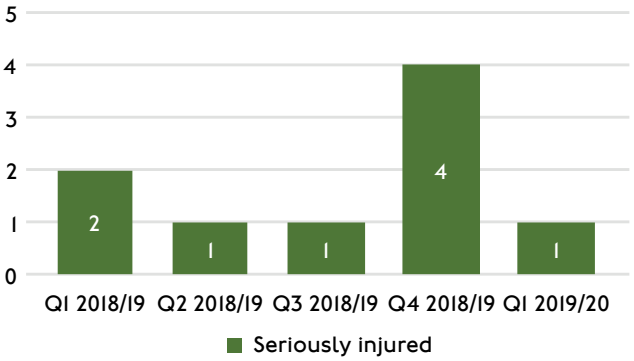
A Vision Zero week will take place in late July for operators to showcase their injury prevention work
The Speed Compliance Tool will be launched
The Bus Safety Innovation Challenge award winners will be announced


Stratford
DLR
101
B

Rail

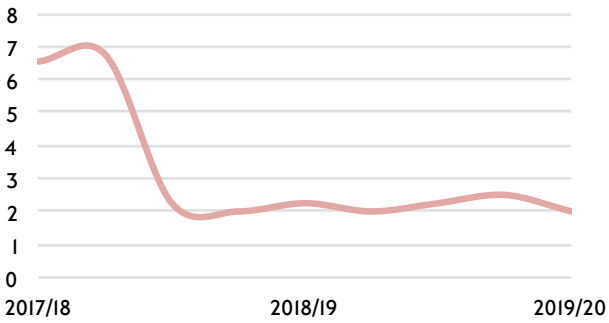
Customers killed or seriously injured

Past five quarters*



One customer was seriously injured on our rail network this quarter. A trespasser broke their leg whilst accessing a locked Sydenham station and was taken from the station to hospital for treatment for their injury.

Moving annual average



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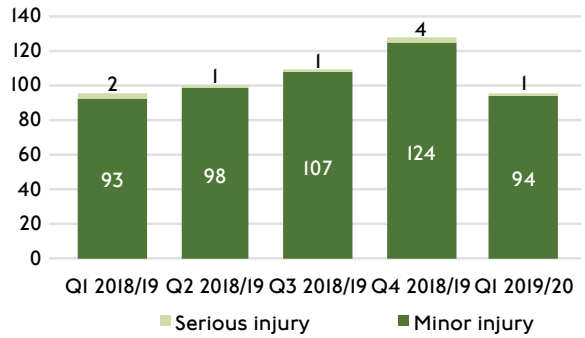
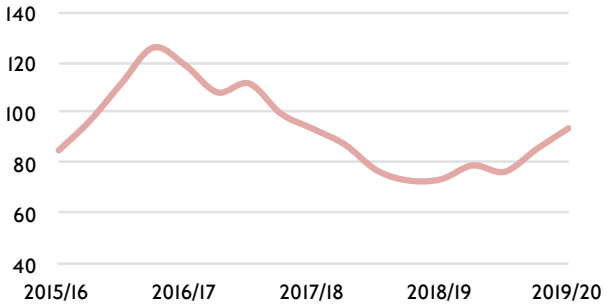
Customer injuries

Past five quarters*



Moving annual average



* Q4 is longer than quarters 1 to 3 (16 weeks instead of 12 weeks).

Injuries by mode

London Overground	39
DLR	14
TfL Rail	37
Trams	5

One of our customers was seriously injured this quarter on the Overground network. There has been a seven per cent reduction in London Overground injuries compared to Q1 in 2018/19.

DLR reported an 18 per cent reduction in customer injuries in Q1 2019/20 compared to the same quarter in 2018/19. TfL Rail injuries reported an increase of 12 per cent**

**TfL Rail safety data is late reported therefore exclude Period 3 in the quarterly figures, and is not broken down by category so included in overall injuriy figures only.

95

Number of injuries on our rail network this quarter (0% against Q1 2019/20)

Did we deliver our planned improvements?

Trams

- Review of the London Trams Safety Management System
  The initial review has identified the London Trams Safety Management Systems mirror our operator's system. Work has now begun on a programme to review the content of common standards. The Joint Safety Risk Model's annual review has been completed and the report is in the final stages of publication
- Issue warm weather travel advice
  Advice and guidance has been communicated to customers during hot weather, via the Passenger Information Displays and Twitter
- Safety campaign
  The "Beware of Quiet Trams" poster campaign has been running across the Trams Network
- Tram safety improvements
  The Light Rail Safety Standards Board (LRSSB) covering the UK tram networks was established in response to the RAIB's recommendations following the overturning of a tram at Sandilands in November 2016. The LRSSB have commissioned the creation of a Safety Risk Model for use across all light rail modes in the UK. During Q1 London Trams and operator Tram Operations Limited (TOL) have been working with the LRSSB to align the current shared Safety Risk Model with the new industry model. Work will continue on this into Q2.

  The iTram system provides driver over-speed alerts. The system is fitted to our Bombardier tram fleet and this quarter, we extended the use of the iTram system to our Stadler tram fleet. We also completed the installation of 'cats' eyes' in the Sandilands tunnel to help drivers differentiate their direction of trave and which section of the tunnel they are in.

  We are also on track to deliver the Rail Accident Investigation Branch (RAIB) recommendations following the over-turning of a tram at Sandilands Junction in 2016.

DLR

- Assess platforms using the RSSB's PTI tool
  Work with the RSSB PTI tool is now complete and all platforms have been assessed. A review of the output is underway to develop any required actions by the end of the year
- The eastern entrance to Shadwell station is often found to be an area of anti-social behaviour, with staff and passengers being intimidated
  Work is programmed for this year to improve the general ambiance, lighting and appearance of this area
- Trespass numbers on the DLR continue to rise from an average of four per period in Q3 of 2018/19 to an average of ten per period in Q1 2018/19
  A number of "high incidence" stations will have 'DO NOT TRESPASS ON THE TRACK' added to the inside lip or the lower platform wall. This will be supplemented elsewhere with "Do not trespass" vinyls.

Overground

- London Overground HSE Assurance Board
  The Board which brings together HSE representatives from all key Overground stakeholders continues to meet periodically and has been a catalyst for increased open dialogue between the stakeholders. The Board has introduced a collective review of customer complaints by all London Overground stakeholders
- Submit the London Overground Safety Authorisation
  The Safety Authorisation submission was made to the ORR in Q1 and shared with all interested parties for comment. The next step will be to address any comments received and provide an updated version to the ORR.

TfL Rail

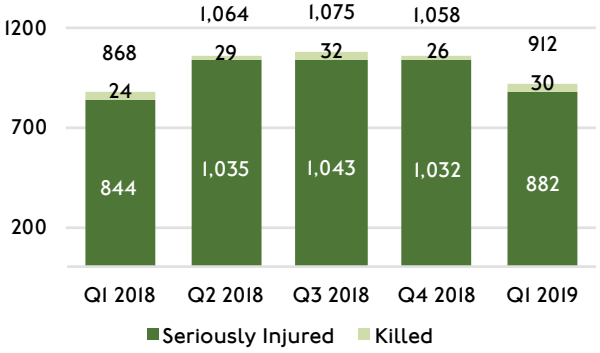
- Launch the Safety Management system for Rail for London Infrastructure
  In April we launched the 'Shadow Infrastucture Manager' project, a six month programme to apply the processes and standards in the Rail for London Infrastructure Management System, in preparation for the Elizabeth line.

Our plans for next quarter

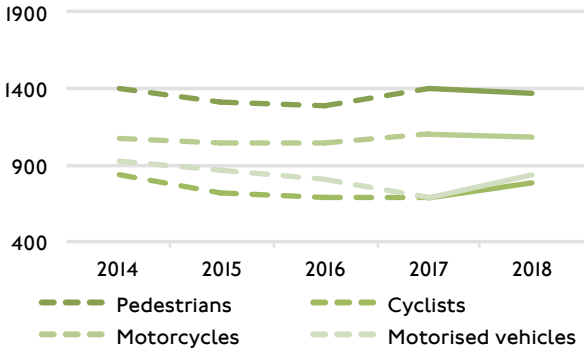
Publish the Trams Joint Safety Risk Model report
Introduction of new 'sharks teeth' stickers on the edges of tram doors to reduce the risk of trap and drag injuries
Identify implications of DfT response to our request for an exemption against the Rail Vehicle Accessibility Regulations requirement for a three-second door closure warning

People killed or seriously injured*

Past five quarters (KSI)



Annual totals*



Figures for 2018 show that 4,065 people were killed or seriously injured on London's roads. This is a 37 per cent reduction from the 2005-09 baseline, but behind the 2018 target required to meet the Mayor's Vision Zero target of a 65 per cent reduction in the number of people killed or seriously injured by 2022.

During 2018 the number of people killed fell to the lowest level on record. There was a reduction in the number of people seriously injured while walking and motorcycling, compared to 2017. However, serious injury among car occupants, increased. The number of people seriously injured while cycling also increased, in particular in collisions involving cars, alongside substantial increases in cycling.

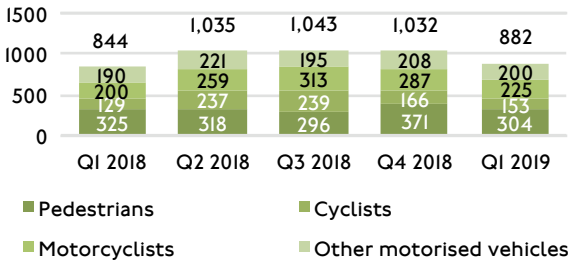
The number of people seriously injured while walking, in particular in collisions involving goods vehicles, fell during quarter 1 of 2019 when compared to the same quarter in 2018. However the number of people seriously injured while cycling or riding a motorcycle increased, in particular in collisions involving cars.

912

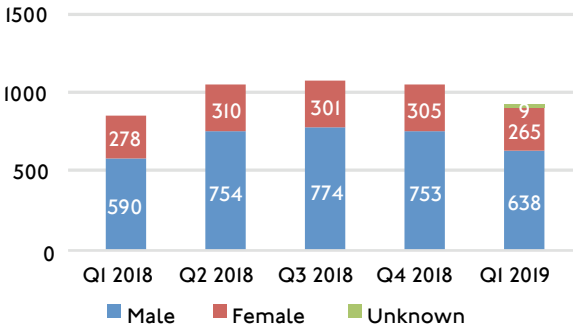
Number of KSI on streets this quarter (5% ▲ compared to Q4 2019/20)

*Figures from the end of 2016 have been reported using a new system. The dotted lines in the graph for calendar years 2013-2016 denote back-estimated figures following analysis undertaken with the Transport Research Laboratory to indicate how many collisions would have been reported under this system in previous years.

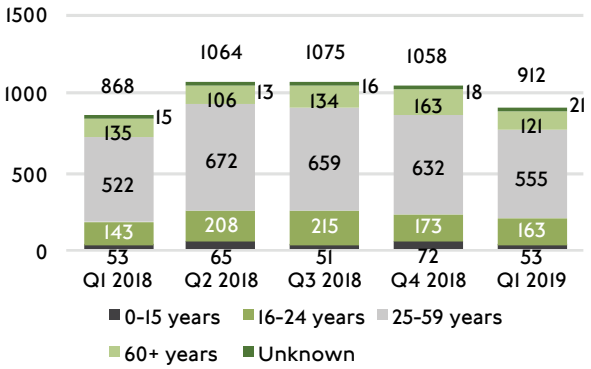
Past five quarters (vulnerable road user)



Past five quarters (gender)



Past five quarters (age)



Older people walking have a significantly higher representation among fatal casualties involving HGVs. To improve older road user safety we have launched a programme to reduce the risk that they experience. Simple tips to older people on how to keep safe around large vehicles have included a leaflet, email marketing to over 60s Oyster card holders and partnership activities with Age UK, raising the awareness of the dangers of vehicle blind spots. HGV drivers have been contacted through the Fleet Operator Recognition Scheme (FORS) newsletter and partner communications to raise awareness of the issue and alert them to high risk locations at Earl's Court Road, Lea Bridge Road, Elephant & Castle, Brixton, Southall and Blackheath.

To target young male riders of motorcycles we provide a free online course known as Pre Compulsory Basic training (pre CBT). This short online course for new motorcycle riders is to teach them essential Highway Code and riding theory. This is an alternative to the formal theory test which new riders taking their Compulsory Basic Training are not required to do. The programme supports the Vision Zero approach to safe behaviours - focusing on tackling the source of road danger. A review of all the programmes that support P2W riders is currently ongoing and will be updated later in the year.

Did we deliver our planned improvements?

- RTPC speed enforcement operations to be completed

  Our high intensity enforcement activity on the A12 continues. In addition to this we have also begun intensive enforcement activity on the A10. We are working with internal and external stakeholders to develop plans which aim to resolve the speeding issues and remove the need for ongoing enforcement activity at these locations.

  Through Operation Challenge, we're trialling a new tactic using numberplate recognition cameras to stop vehicles identified as high risk to the public, including: repeat or high risk speeders, disqualified drivers, non-compliant vehicles, drivers who have had their licence revoked on medical or age grounds, gang members. In its first two weeks, Operation Challenge has resulted in 23 arrests, with drivers also responsible for a variety of offences including drug driving, vehicle theft, possession with intent to supply class A drugs, armed robbery, domestic assault and GBH

- Freight operator recognition scheme event

  We held an industry event on 26th April aimed at key stakeholders including industry representatives and specifying organisations. The group was unanimous in its approval of the updated operational model presented. A further event is scheduled for 6th September to announce the future direction of FORS and to start the re-tender to create a direct service contract to TfL for governance and standards of the scheme

- Publication of Direct Vision Standard (DVS) consultation response

  Following public consultation, statutory consultation started in April 2019 for the introduction of this standard which could be applied to prevent vehicles with the lowest ratings from entering London from 2020. Public consultation closed in May 2019 and no objections were received to necessitate a public enquiry. We expect London Councils to confirm the Traffic Order Regulation (TRO) by August 2019. The registration system to enable HGV drivers to apply for DVS permits will go live by the end of 2019. DVS contributes directly to the Mayor's Vision Zero objective to eliminate death and serious injury from London's roads

- Delivery of the Safer Junctions programme, including starting the main construction at Old Street and Highbury Corner

  We have now completed work at 30 of the most dangerous junctions on our road network, defined as those with the highest vulnerable road user collision rates. Twelve more are planned for completion by spring 2020. Public consultation on five Safer Junction schemes started in June, with engagement planned on a further four locations over the summer. We continue to review the completed projects to ensure they have successfully reduced collisions, and overall there is currently a 28 per cent average reduction in the incidence of collisions across the improved junctions.

  Work continued at Highbury Corner during Q1 to build the pedestrianised area on the western side and complete the segregated cycle lanes. Construction will be complete in September 2019.

  We also continued our works at Old Street which will bring safety improvements to

people cycling and walking including new and improved crossings, fully segregated cycle lanes, a new public space with a main accessible entrance to the underground station and the shopping arcade. Advanced construction works to remove the traffic islands on all four arms of the roundabout are complete and the traffic switchover to two-way operation was achieved over the late May bank holiday weekend. This is a temporary switch, which closes the southeast arm of the junction to traffic to enable construction of a new entrance to Old Street underground station near to Cowper Street. Later this year, a further traffic switch will be required to reopen the southeast arm and permanently close the northwest arm facilitating the construction of the public space and accessible main station entrance. Planning consent for the new main station entrance is expected from Islington Council in September 2019. Construction is on track to be completed by the end of 2020

- Public consultation to begin on future cycle routes and schemes

  In May 2019, the length of protected cycle infrastructure surpassed the 2016 baseline of 53km, with 116km complete or under construction. This includes improvements for people cycling and walking between Acton and Wood Lane along the A40, which started construction on 18 March while major carriageway works started in early April. Other recently completed schemes include new pedestrian and cycle crossings at Edgware Road, which remove a key barrier on Quietway 2, and a route connecting Kensington High Street to Notting Hill. We have also introduced new crossings for people walking and cycling across Euston Road at Judd Street and new segregated cycle lanes on Midland Road as part of Cycleway 6, providing a cycle route all the way between Elephant & Castle and Kentish Town. Construction work is also progressing well in the three Mini Holland boroughs with 32 of the 103 Mini-Holland schemes now complete, including the A105 Green Lanes scheme, a five-kilometre protected cycle route linking Enfield Town to Palmers Green and installation of a new bridge for people walking and cycling adjacent to Kingston Station. Construction is due to start on a number of major routes this year including Cycleway 4, which began on 5 July, and Cycleway 9 in autumn.

  Work continues on several major new routes, identified in the Strategic Cycling Analysis published in 2017. Public consultations for walking and cycling improvements opened in May for routes between Hackney and the Isle of Dogs and Wood Lane and Notting Hill Gate, and for the route between Ilford and Barking Riverside in June. We also plan to consult the public on a number of other routes across the next year including the Lower Road section of Cycleway 4 and routes between Dalston and Lea Bridge, Greenwich and Woolwich and Camden and Tottenham Hale

- Ongoing support and focus on the opportunities for London boroughs to champion Vision Zero

  Following the dashboard summary of key borough casualty statistics provided to borough Leaders, Chief Executives and Heads of Transport in December 2018, we have continued to engage with London boroughs to highlight the importance of Vision Zero and the imperative to embed

it within their organisations. We held the second of a series of events in partnership with the London Road Safety Council, to further educate elected members across London of the importance of prioritising Vision Zero in their borough. The sessions were well received, and members committed to go further in embedding Vision Zero in their boroughs

- Develop our understanding of the care and support required for road crash victims
  Following a meeting in January to develop our understanding of the experience of those that have been personally touched by fatal or serious road injuries, we have held a series of meetings with victims of road trauma, as well as the organisations that seek to support them (including Brake and Roadpeace). These meetings have helped us to develop our understanding of the current support offer available to victims of road crashes, so that we might further improve the care provided for these individuals. We will look to understand how gaps in the level of post collision care offered can be filled and how TfL can further support the process

- Lower Speed Limits
  In July 2018, the Vision Zero Action Plan set out our commitment to introduce a 20mph speed limit on the TfL Road Network (TLRN) in central London by May 2020 (Phase 1) and lower the speed limit on a further 155km of TLRN by May 2024 (Phase 2). Phase 1 concept design and consultation completed on 10 July, with analysis of the consultation results now underway. Phase 2 of the programme has also mobilised and has started to integrate lower speed limits into existing projects, to accelerate delivery as far as possible. Proposals will include a mix of signs, lines, physical infrastructure and speed cameras.

  We have finalised a draft of the Lower Speeds toolkit following consultation with London Councils and other stakeholders. The toolkit is not intended to act as design guidance and does not seek to replace or review any technical literature or policies previously published. The document summarises and signposts relevant technical guidance that the reader can go to for more detailed/engineering information. We are currently working with partners to explore opportunities for co-branding and support and will look to publish the document as soon as possible

- Vision Zero week
  During the quarter we prepared for Vision Zero week in July, marking one year since Vision Zero launched and generating awareness of what Vision Zero is seeking to achieve by having focused communications efforts from all stakeholders at one time. This includes the launch of the 'Know My Name' Campaign, sharing the stories of how road trauma impacts on people and communities. Working with our advocacy group we will tell their stories in the media and online, utilising video and imagery for maximum impact, and making use of TfL channels. The Vision Zero badge also launches during Vision Zero week. Our partner badge can be displayed on stakeholder's assets to showcase support for achieving Vision Zero. The Vision Zero badge will provide a unifying identify to group activity across TfL, London boroughs, our emergency service partners and others to achieve Vision Zero.

Our plans for next quarter

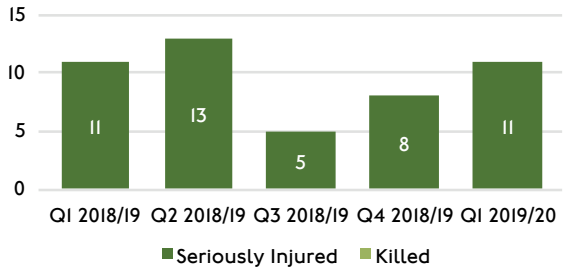
Hold Vision Zero week to raise awarenes
Launch the 'Know my name' campaign to communicate the impact of road trauma
Publication of 2018 road casualty data
Localised interventions at high-risk locations
Pedestrian behaviour and risk management research
Continue to embed Vision Zero and a strong safety culture
Operation hornets targeting e-scooter users to educate them about the law and prevent use on public roads


TAXI
LTI
Transport for London
Public Carriage Office

Other operations

Customers killed or seriously injured

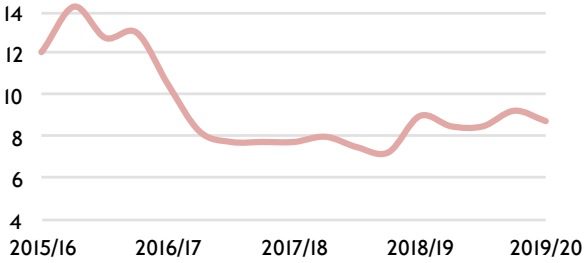
Past five quarters*



*the above figures overestimate the number of people seriously injured.

Eleven incidents have been classified as serious injuries in Q1. This is the same as Q1 last year. There has been a quarter on quarter increase since Q3 last year. Whilst the increase has been seen in the quarterly figures, the moving annual average is showing a downward trend in Q1 2019/20.

Moving annual average



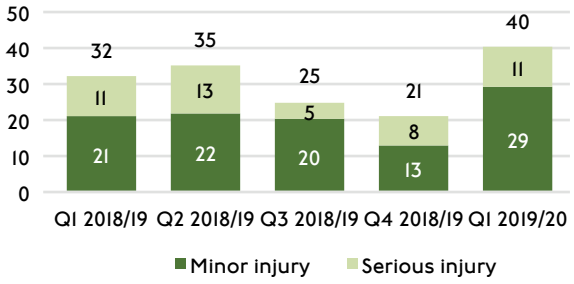
Santander Cycle Hire had a total of six customers seriously injured in the quarter, this is an increase of one on Q1 last year.

Dial-a-Ride reported five serious injuries, which represents a reduction of two on last year.

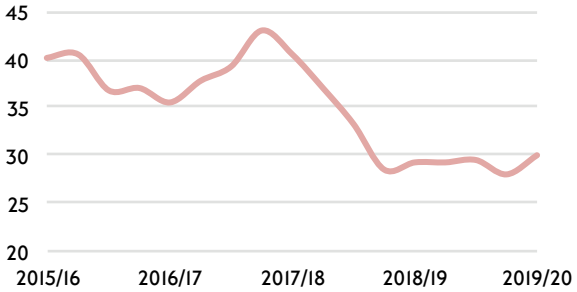
There were no KSIs reported on the London River Service or Victoria Coach Station.

Customer injuries

Past five quarters*



Moving annual average



* Q4 is longer than quarters 1 to 3 (16 weeks instead of 12 weeks).

Top cause of injury (%)

Slips, trips and falls	40
Cuts / abrasion	25
Struck by object	13

40
Number of injuries within our other operations compared to 32 last year (25% ▲ on Q1 2018/19)

Forty customers were injured as a result of our other operations in the quarter:

- Eleven customers were injured on Dial-a-Ride (reduction of one on Q1 2018/19)
- Ten customers were injured on Cycle Hire (increase of five on Q1 2018/19)
- Ten customers were injured on London River Services (increase of six on Q1 2018/19)
- Six customers were injured on Victoria Coach Station (reduction of one on Q1 2018/19)
- Three customers were injured on Emirates Air Line (reduction of one on Q1 2018/19).

This is a 25 per cent increase (eight minor injuries) compared with the same quarter last year, largely due to an increase in injuries on Cycle Hire and London River Services (LRS). LRS has been encouraging more openness with safety on the river, which in turn has improved the volume of safety incidents reported.

Slips, trips and falls remain the biggest cause of injury on other operations (40 per cent).

After a relatively static performance during 2018/19 there has been a slight increase in the moving annual average at the start of 2019/20.

Did we deliver our planned improvements?

Through the Thames Partnership Group (TfL, Port of London Authority and the Maritime Coastguard Agency) we launched the HSE improvement plan for the Thames during QI. Progress against the plan will be monitored on a periodic basis. All improvement actions are on target.

In support of the plan, we led a series of boat operator forums during the quarter. This promotes a new way of working with boat operators to acheive the common goal of safe operations on the river.

The programme of repairs to safety chains and ladders on our piers is slightly ahead of programme. All work at Millbank pier is complete and new overboard ladders have been installed at Bankside pier.

A project is underway to retrofit GPS trackers to 500 new cycle hire bikes. As well as providing information on the use of the cycle hire scheme, the project also assists with the recovery of lost bikes, which will help prevent them becoming a hazard or nuisance. The first tracked bikes are expected to be available by the end of the year.

Physical improvements have been made to the road surface and markings within the arrivals terminal at Victoria coach station, to assist coach drivers postioning vehicles in the terminal.

Our plans for next quarter

Continue to engage with all Thames stakeholders to improve customer and staff safety through active monitoring and operator licencing requirements
Dial a Ride will launch its “Reversing the Risk” training course for drivers, aimed at improving their manoeuvring competency in tight suburban streets to reduce minor collision incidents

Safety - feedback from customers

Number of complaints

	Q1 2018/19	Q1 2019/20
Underground	245	233
Buses	998	1034
DLR	22	24
London Overground	18	23
TfL Rail	12	15
London Trams	3	11
Emirates Air Line	0	0
Congestion Charge	0	0
Dial-a-Ride	3	2
London River Services	4	0
Santander Cycles	0	0
Taxis*	2	2
Private Hire*	0	1
Total	1307	1345

* Taxi and private hire complaint numbers are not directly comparable due to the way they are received and recorded

There was a nominal increase in overall safety contacts from customers compared to last year, this is due in part to the new and improved way the Contact Centre now records safety contacts.

Buses remain the area with the most safety contacts with a slight increase from last year. Passenger incidents and injury claims were the highest reasons, alongside collisions with other vehicles and property damage. London Underground saw a slight fall in safety contacts, with common themes being incidents involving doors, escalators and injuries to customers. Trams have seen an increase in safety contacts against this time last year, though numbers remain low. These mainly relate to speeding and sharp braking resulting in injuries.

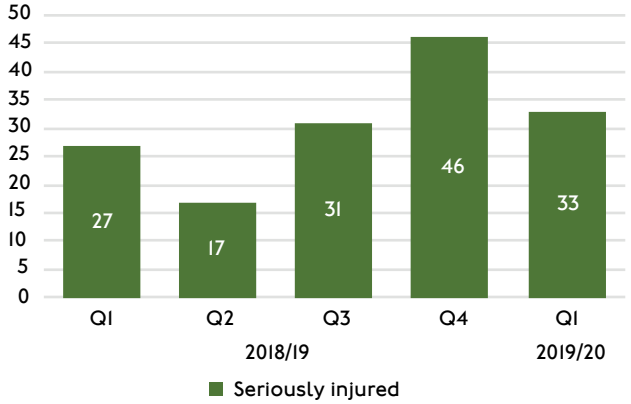
All safety critical contacts are actioned within 24 hours.


VolkerRail
VolkerRail
35

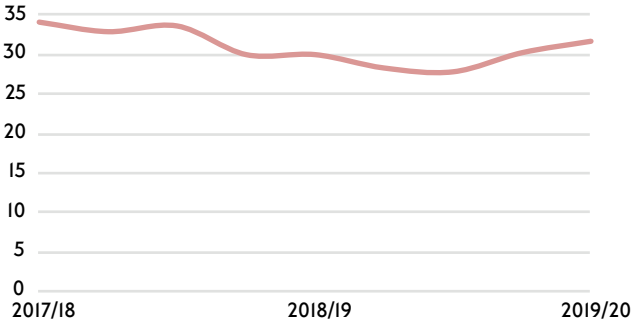
Workforce

Workforce killed or seriously injured

Past five quarters*



Moving annual average

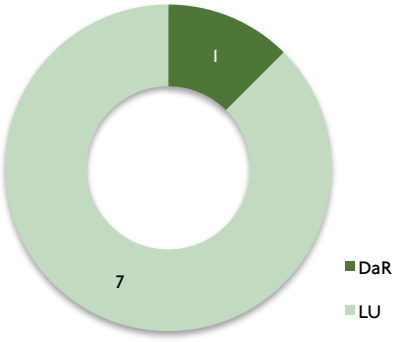


*the above figures overestimate the number of people seriously injured.

There were 33 incidents classified as seriously injured during quarter one. This represents an increase of six in comparison to Q1 last year.

61 per cent (20) were on London Buses, this is a decrease of three incidents on Q1 last year. This is followed by Others Ops and London Underground with 33 per cent (11) and six per cent (two) respectively.

The moving annual average is showing an increasing trend, this is largely due to the peformance on London Buses as they account for 75 per cent (116) of all killed or seriously injured classified injuries on the TfL network in the past five quarters.



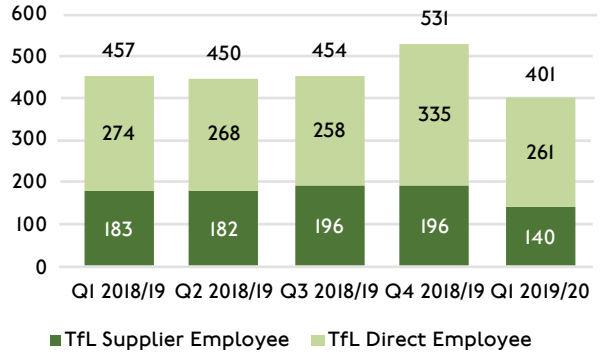
RIDDORs

There were 48 reportable incidents affecting our workforce of which 46 were in LU and 2 in Surface.

Assaults (24%) and slips, trips and falls (39%) were the main causes of RIDDOR reportable incidents in the quarter.

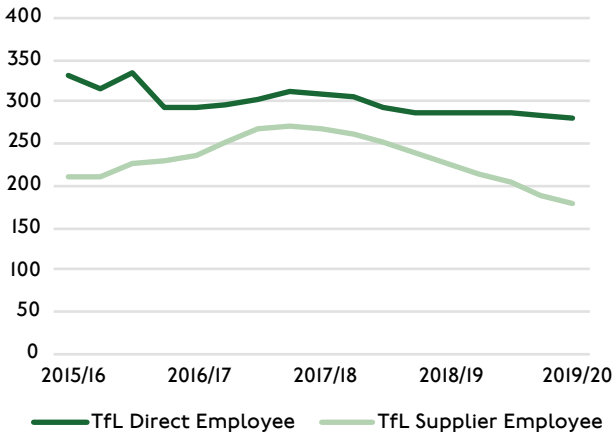
Workforce injuries

Past five quarters*



* Q4 is longer than quarters 1 to 3 (16 weeks instead of 12 weeks).

Moving annual average



There were 401 workforce injuries in Q1 2019/20. This is a reduction of 12 per cent (56) when compared to the same quarter last year (five per cent fewer injuries to direct employees and 23 per cent fewer to supplier employees).

Of the injuries, 59 per cent occured within LU and 21 per cent in Buses. The rest was made up of Rail (eight per cent), Other Operations (four per cent), Major Projects Directorate (MPD) (four per cent) and Other Support Areas (three per cent).

Direct employees

Our direct employees accounted for 65 per cent of total workforce injuries. Of these, 89 per cent occured in LU. The moving annual average is 281 per quarter for direct employees, which is two per cent lower compared with Q1 2018/19.

Supplier staff

Our supplier staff injuries accounted for 35 per cent (140) of total workforce injuries. The biggest contributor to supplier staff injuries was from Buses with 84 injuries. The trend in supplier staff injuries is improving; the moving annual average is 21 per cent lower than the same time last year. This is due to fewer supplier injuries on our major projects and LU (including TfL Rail).

235

Number of workforce injuries on the LU network this quarter (1% ▲ compared to Q1 2018/19)

84

Number of workforce injuries on the Bus network this quarter (24% ▼ compared to Q1 2018/19)

39

Number of total construction workforce injuries quarter (24% ▼ compared to Q1 2018/19)

Did we deliver our planned improvements?

Operations

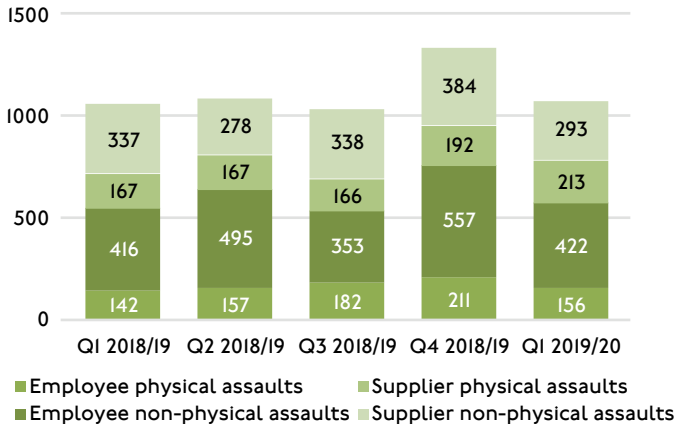
- Ongoing safety leadership and staff engagement
  We have developed our workforce engagement plan and continued to deliver safety awareness day and night visits. We have delivered the safety awareness sessions to over 1000 of our people
- Improve LU's processes for communicating operational messages
  There can be significant safety risks associated with poor communication of safety information in an operational environment. The new LU operational communication framework was launched in Q1 and communications and process updates sent out to all areas in LU and to everyone who works on our infrastructure. The ezone course was launched and concertina cards issued as a quick reference guide for all LU staff
- HSE Risk Management Improvement project
  The HSE teams across TfL are working together to improve how health, safety and environmental risks are assessed and managed. This quarter we have developed high level plans, contacts and started engagement with senior managers and Trades Unions
- Body worn cameras
  The trial of body worn cameras was undertaken on 12 stations and findings are being reviewed. There will be further testing on stations as a result of the review
- Near miss app
  Following ther successful trial of our new near miss reporting app earlier this year, the near miss reporting app was trialled on six LU stations. Findings will be monitored and reviewed to inform our decision on further rollout
- Diversity & inclusion
  Women who work in our engineering, maintenance and construction teams now have access to probably a world-first in the rail industry.The personal protective equipment (PPE) available to our workforce now includes a high visibility safety dress/tunic that is more suitable for women, particularly those with a dress code based on their culture or religion.

Our plans for next quarter

The near miss reporting app will be trialled further and promoted in maintenance workshops
The new monitoring regime for Operational Communications will be launched
The results of the body worn camera trial on LU will be reviewed and next steps agreed
The new risk management course will be launched across TfL
The roll out of new workplace risk assessments will start with LU Office teams
Dial a Ride will launch its “Reversing the Risk” training course for drivers, aimed at improving their manoeuvring competency in tight suburban streets to reduce minor collision incidents

Violence against our staff

Past five quarters*



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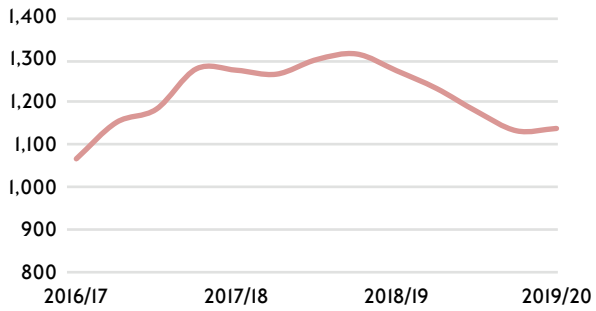
Moving annual average



The moving annual average was trending positively at the end of last year but has seen a slight increase going in to 2019/20.

Types

Physical assaults	369
Non-physical assaults	715
Total assaults	1084

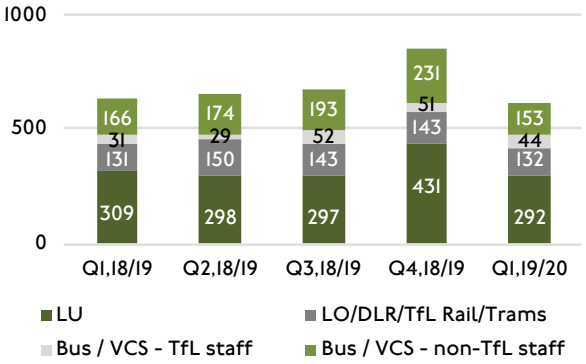
There were 369 incidents of physical violence against our staff in Q1 2019/20. This compares to 309 in Q1 2018/19, an increase of 60 (19 per cent).

There were 715 incidents of non-physical violence against our staff in Q1 2019/20. This compares to 753 in Q1 2018/19, a decrease of 38 (five per cent).


Platform 12
Stansted Airport
Way out
Trains
BRITISH TRANSPORT
POLICE

Police recorded violence

Police recorded violence / public order offences against staff (volume)



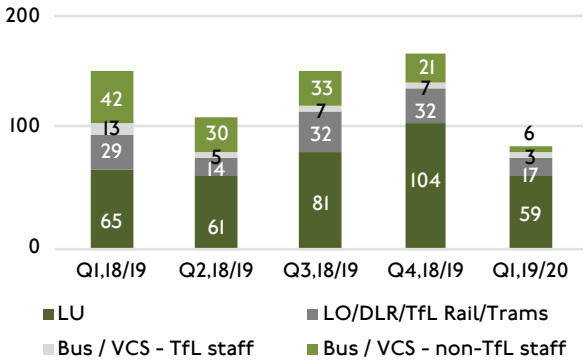
We work closely with the Metropolitan Police (MPS) Roads Transport Policing Command and the British Transport Police (BTP) to support investigations into violence (physical and non-physical) towards our workforce.

We are currently developing our first ever pan-TfL Workplace Violence and Aggression Strategy. It is imperative that our people, and the workforce of our suppliers and contractors, feel safe and supported and we are determined to do more to tackle workplace violence and aggression against our people. Part of our improvement activity includes improving the quality of our reporting, data and analysis to gain a deeper understanding of trends and issues to better target actions. Future HSE quarterly reports will include more insight as this work progresses.

In Q1 the police recorded the following - violence/serious public order offences against staff:

LU	292
Bus / VCS non TfL staff	153
LO / DLR / TfL Rail / Trams	132
Bus / VCS TfL staff	44

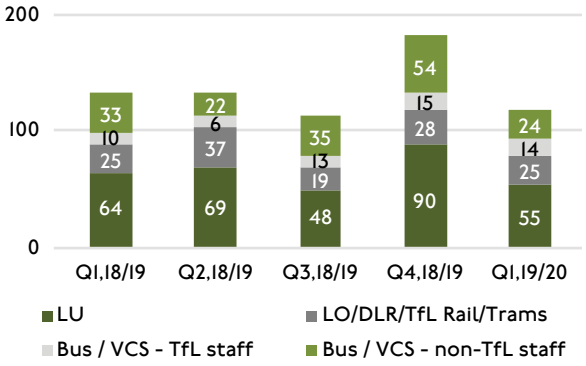
Positive outcomes of police recorded violence / public order offences against staff (volume)



In quarter 1 (periods 1-3) the overall positive outcome rate was 14 per cent. This value fluctuates greatly between the BTP and the MPS and is reflective of the live nature of ongoing investigations with many cases open at time of reporting. The majority of recorded staff assaults were on the bus and LU networks (32 per cent and 47 per cent respectively), with the positive outcome rate for this quarter being 5 per cent on the bus network and 18 per cent on the BTP-policed TfL networks.

Police recorded violence

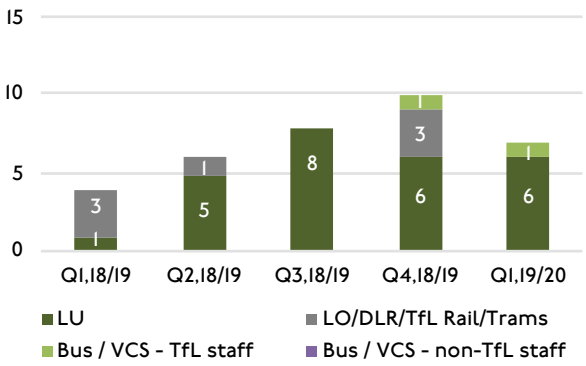
Police recorded violence / public order offences against staff which are deemed a hate crime



The police will flag an offence as a hate crime if it is motivated by one of more of the factors of race, religion/faith, sexual orientation, disability or transgender identify. Tackling hate crime against our staff and customers is a priority for us and our policing partners. We lead a range of activities to deal with hate crime on our transport network to reassure our staff and passengers who feel more vulnerable to victimisation, and encourage people to report incidents to the police.

In quarter 1 (periods 1-3) the proportion of offences against staff deemed hate crime was 19 per cent, a slightly lower rate than the preceding quarter, and also lower Q1 2018/19. The majority of hate-related staff assaults are racially motivated (in excess of 80 per cent) and this is consistent across all modes.

Sexual offences against members of staff



The volume of offences remains low and relate to exposure and unwanted touching.

We continue to work with the BTP, City of London Police and the MPS on Project Guardian, a partnership initiative to increase the confidence in reporting sexual offences which occur on the London's public transport system, reduce the risk of becoming a victim, challenge unwelcome sexual behaviour and target offenders.

In quarter 1 (periods 1-3) the volume of sexual offences against staff was low with the majority occurring against LU staff, and relatring to unwanted touching or exposure.

Did we deliver our planned improvements?

- Work on a pan-TfL strategy for tackling workplace violence and aggression (WVA)
  The strategy is on schedule to be presented to the Safety Sustainability and Human Resource Panel (SSHRP) in September
- Additional staff peer support training was delivered
  We have extended our tailored two day Trauma and Stress Support Foundation Training course further across the business. This focuses on the provision of peer to peer support for those who experience psychological trauma and work-related stress. It provides skills to help colleagues within set boundaries and this is supported via bi-annual supervision / good practice days, which are delivered by Occupational Health. This two-day training enables attendees to join the trauma & stress support group (TSG). There are currently approximately 190 operational staff (including train drivers, station and on-street staff and emergency response units) who participate in TSG
- We held a very successful staff engagement workshop to inform the development of the pan-TfL WVA strategy
  The workshop was held on 21 June at Pier Walk. Over 100 operational and customer-facing staff from across the business attended
- We have increased the number of joint British Transport Police (BTP)/Revenue Control team exercises
  We are focussing BTP deployment at those stations which experience greater levels of workplace violence or intoxicated customers
- A number of recent studies have shown that body worn video (BWV) is effective in reducing assaults on staff
  The presence of visible cameras can deter customers and members of the public from acting violently or aggressively and can also provide valuable evidence against offenders. Our London Underground Revenue Control team have all been issued with BWVs, and in April we distributed them to 12 LU stations. In August / September, BWVs will be rolled out to a further set of stations
- Learning from the recent studies and our own trial is being used to inform the development of a pan-TfL business case for BWV in line with operational requirements
- The British Transport Police has launched its 'Focused On Your Safety' campaign which aims to reassure our staff and passengers and deter offenders by highlighting the range of tactics being used to deter and detect crime, including our network of uniformed police, plain-clothed officers and an extensive CCTV network.

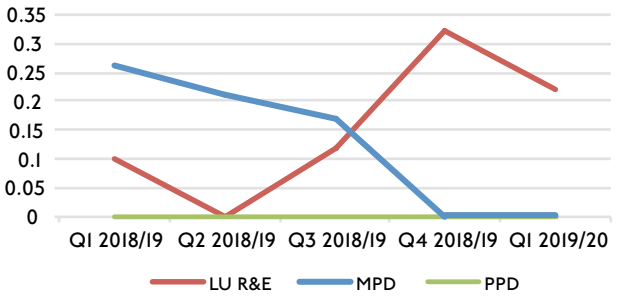
Our plans for next quarter

Present the pan-TfL strategy to tackle workplace violence and aggression to the Safety Sustainability and Human Resource Panel
Develop a joint pledge between TfL, British Transport Police and Metropolitan Police to prevent workplace violence and aggression, provide enhanced care and support and to become a learning organisation
Establish a joint workplace violence steering group with the Trade Unions
Continue to work with our police partners to tackle the common triggers to WVA and to improve police visibility and engagement
Deliver Trauma and Stress Support Foundation Training
Finalise a joint pledge between TfL, British Transport Police and Metropolitan Police on workplace violence and aggression for our staff

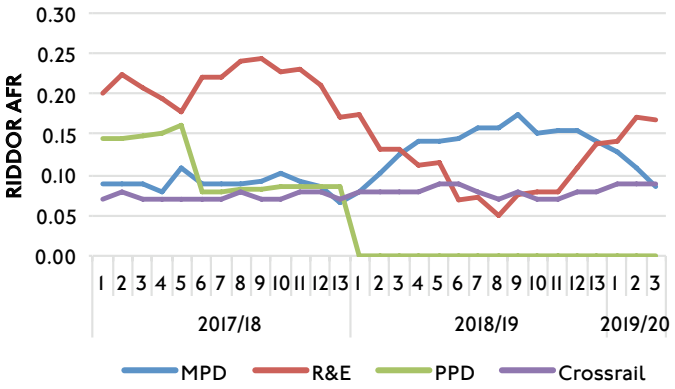

Select
Select

Workforce injuries - construction

Construction workforce accident frequency rate



Moving annual average



Our construction workforce accounted for 39 of our workforce injuries in the quarter. This is a 7 per cent decrease on quarter 1 last year. None of the injuries in the quarter were reported under RIDDOR. There were no serious injuries in the quarter compared to five in quarter 1 of 2018/19.

Top causes of injury (%)

Machinery / equipment / powered tools	10
Manual handling	23
Slips / trip / falls	13

For our direct employees, manual handling was the main cause of injuries in quarter 1. The majority of the direct employee injuries occurred within LU where there continues to be a stable trend since the start of 2017/18. Machinery / equipment / tools was the second most common cause of injury for our construction workforce within LU and MPD.

On 17-18 April an engineering train was used for the first time to deliver construction materials along a section of track, for the later installation of post bases. This was the result of some detailed planning work, and was successfully carried out. There will be benefits not just for efficiency on programme delivery, but also a reduction of manual handling of materials previously moved by track trolley.

On Crossrail, the RIDDOR Accident Frequency Rate (AFR) increased this quarter from 0.08 to 0.09 which remains below the target of 0.13 and equal to the highest rate in 2018/19 (0.09 in quarter 2) and higher than the rate of 0.08 in quarters 1, 3 and 4 of 2018/19.

Did we deliver our planned improvements?

- Summer safety campaign
  In response to a recognised spike in incidents during the summer months when fatigue and distraction play a part, we launched a summer safety campaign across our major projects to highlight the risks associated with warm temperatures. Briefings were given to the MPD staff to provide advice and support, specifically around heat stress, scheduling work responsibly, sun exposure and preventative measures for people whose job keeps them outdoors for a long time. The summer campaign material was shared with our supply chain. Early indications suggest that there have been fewer injuries, significantly less lost time injuries and no RIDDOR reportable injuries this year, compared with the pot-holiday period last year

- Re-design our TfL staff HSE induction for those who visit our or our supplier's construction sites
  Work has begun to evaluate the use of Virtual Reality (VR) head sets to modernise the existing Worksite Safety Induction Assessment. VR is a proven effective method of delivering training which is consistent, interactive and measureable within an "authentic" scenario addressing real risks

- Launch "Be the best Client we can be"
  A joint meeting was held with representatives from the TfL Supply chain to discuss their perception of TfL as a responsible Client. It was an open and frank discussion resulting in a number of key points raised with opportunities for both TfL and its suppliers to improve the relationship; providing an environment in which our suppliers can deploy HSE innovations that reduce harm. The first action has established a periodic meeting between all four TfL capital delivery Directors to discuss key issues and develop a consistent approach to HSE management across all our construction activities

- Roll out "Who am I safe for?" across TfL
  The 'who am I safe for' cultural improvement programme to help people consider the consequences that unsafe actions at work could have on their home-life launched in our major projects is rolling out across TfL. Supporting materials were issued in April to our supply chain to engage with this successful initiative. The 'Who Are You Safe For?' campaign has improved and fostered more meaningful two-way conversations about HSE with employees and external contractors and suppliers. The campaign has been embraced in many areas of TfL delivery and supply partners. A compilation of outputs and findings from the campaigns is being undertaken and will be shared across TfL

- Construction Design Management Regulations (CDM) 2015 awareness sessions
  To improve the knowledge and skill set of the project delivery teams in TfL, we launched a range of Construction Design Management Regulations (CDM) 2015 awareness sessions. Four courses have been established; an online awareness course, and courses that focus on the roles and responsibilities of the three key CDM roles, Client, Principal Designer and Principal Contractor

- Sharing best practice
  TfL chaired the Network Rail Southern Shield Best Practice group. Members are committed to sharing new or innovative ideas being employed within their businesses as a result of operational learning for the greater good of the industry. Attendees came from Network Rail supply chain but there is a crossover to TfL supply chain. The theme of the day was Being Safe on the Railway with presentations from LU protection and possessions team that showed the difference between both organisations. This was followed by a dedicated Protection & Possessions presentation to key Network Rail access leadership team members on 20th May. The “Who am I Safe For” campaign was presented and included a video showing the campaign in action at Ealing Common Depot where TfL is the Principal Contractor

- Other key activities
  In response to the tragic news that two experienced Network Rail track workers, sadly lost their lives in a track incident at Port Talbot in July we have worked across the business to refresh messaging around our and our suppliers’ approach to track safety through bulletins and facilitated conversation on our sites. Track safety was already one of our priority risk areas that we focus on and have improvement the plans for. Following the tragic incident at Port Talbot we have reviewed and accelerated our plans. We have driven the establishment of a senior level steering group and a corresponding task force to consider improvements to how we as an organisation work on and around track in LU, including the introduction of technological solutions to help further reduce risk.

  In collaboration with our delivery partners on our Barking Riverside Extension (BRE) site we have lead improvements on safe digging practices in response to two utility strikes. Whilst no one was hurt in either incident the project team has been galvanised to ensure such strikes are not allowed to happen again. Improvement includes revisions to process and documentation giving authorisation to dig, enhanced supervision and engagement with operatives on site and a continual cultural improvement on the site lead through our supplier team, supported by us. Opportunities will be taken via our regular engagement events to share this learning across our supply chain.

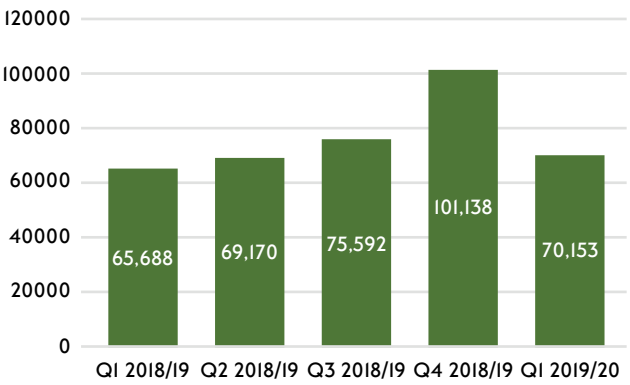
Our plans for next quarter

Launch the 'Connecting with site' campaign across our major projects
We will continue the improvement to 'Be the best client we can be'
Launch the revised Beacon award scheme across TfL for maintaining consistent high standards of site safety

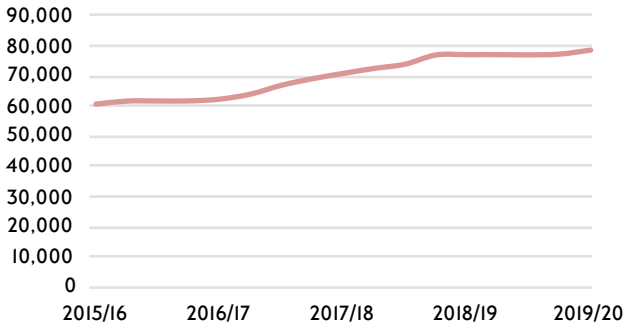
Sickness, absence and wellbeing

Days lost to sickness

Past five quarters*



Moving annual average



*Q4 contains 4 periods rather than 3.

During Q1 in 19/20, 55 per cent of staff absence was attributed to musculo-skeletal, mental health and assaults/injuries which are the top 3 causes of sickness days. This is the same percentage attributed to the top 3 causes when compared to the same quarter in 18/19.

Overall sickness days increased by 6.8 per cent in Q1 2019/20 when compared to the same quarter last year.

70,153

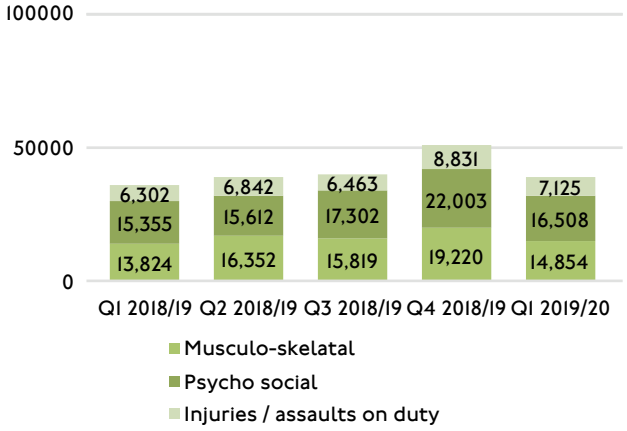
Working days lost to sickness (6.8% ▲ compared to Q1 2018/19)

4.87

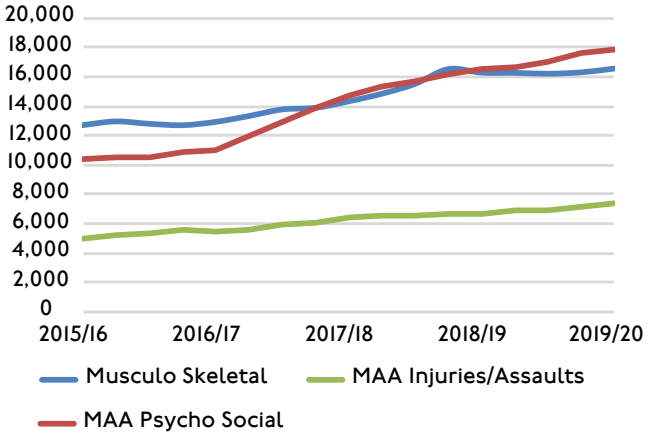
Percentage working days lost to sickness (13% ▲ compared to Q1 2018/19)

Days lost due to sickness

Past five quarters*



Moving annual average



* Q4 is longer than quarters 1 to 3 (16 weeks instead of 12 weeks).

There were increases in all top 3 causes in Q1 2019/20 when compared to the same quarter in Q1 18/19 as follows:

7.5 per cent increase in musculo-skeletal sickness
7.6 per cent increase in mental health sickness
13.1 per cent increase due to accidents and assaults.

Did we deliver our planned improvements?

- Mental Health Awareness Week
  We supported the Mental Health Awareness Week, run by the Mental Health Foundation. The theme for this year was Body Image – how we feel and think about our bodies.

  During the week we provided tips on Yammer about treating your body with respect, eating well-balance meals and exercising, surrounding yourself with positive friends and family and being mindful of messages coming from the media

- Mental Health Awareness at Work e-learning
  We also launched a new Mental Health Awareness at Work e-learning training, which will be available to all TfL employees via our online training portal. The e-learning course covers:
  - Introduction to mental health and wellbeing
  - Overview of common mental health problems - depression, anxiety and stress
  - The role of mental health in our working lives
  - Stigma and how it impacts on our mental health
  - Raising awareness of workplace wellbeing
  - Tips on self-care
  - Potential triggers of poor mental health in the workplace
  - Building resilience
  - Supporting others

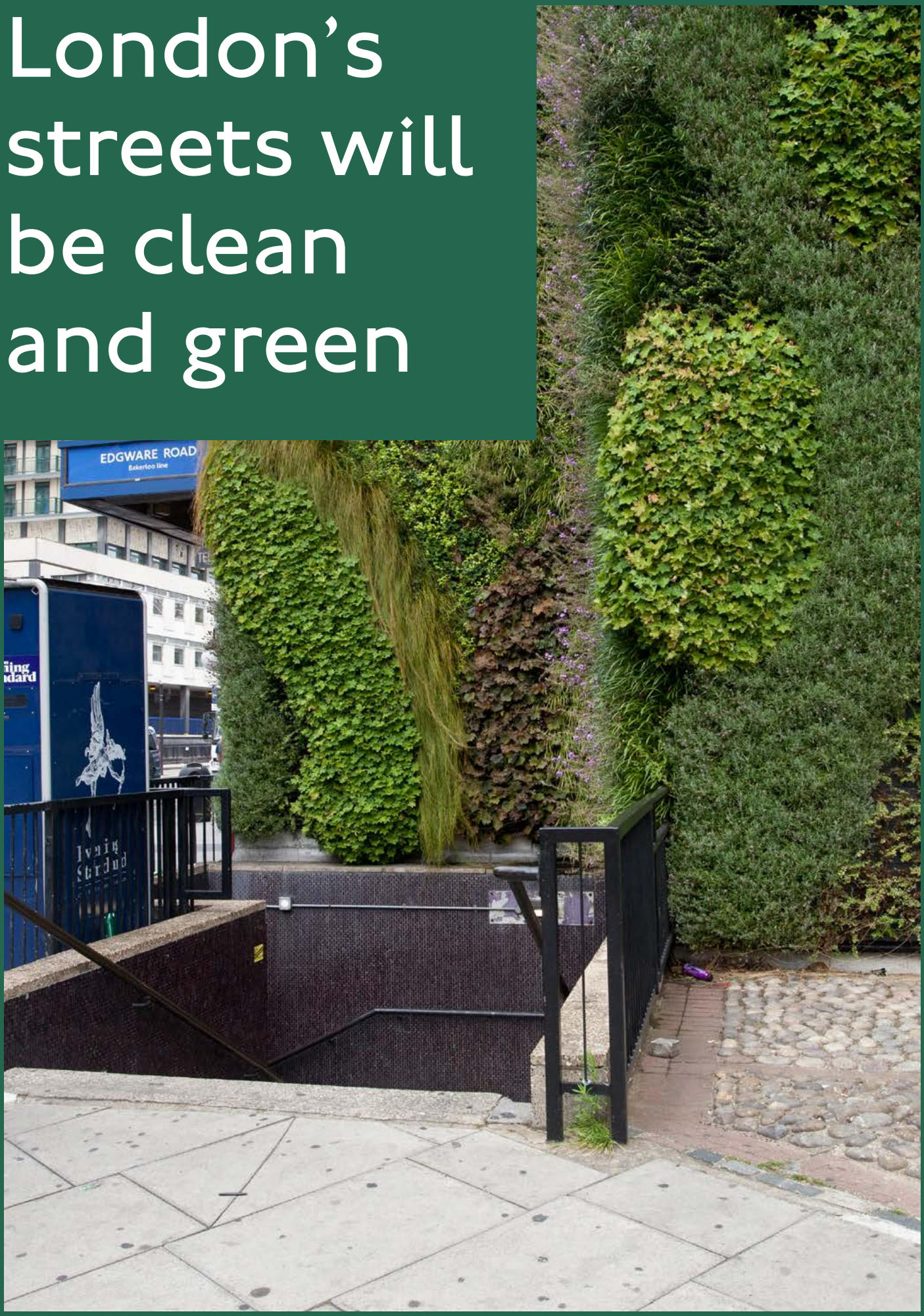
- Green Ribbon Pin Badge
  The green ribbon is the international symbol for mental health awareness. All our Peer Supporters – Time to Change Agents, Supporting Colleagues Network, Trauma Support Group and Health and Wellbeing Champions – were issued with a Green Ribbon Pin Badge during the course of May. The Pin Badge will show their support for mental health in the workplace and will help employees identify them as a point of contact for mental health issues

- Time to Change Agents
  In June we recruited and trained a further 24 Time to Change Agents (TtC). The Role of a TtC Agent:
  - Help TfL to become a mentally healthy workplace where talking about our mental health becomes a natural and everyday occurrence in TfL.
  - Be a key point of communication for the team / area / function they represent for all TtC information
  - Be open to talk to any colleagues about the importance of mental health and breaking the stigma
  - Can assist colleagues and refer them to what support is available for them

- Go jauntly in June!
  To encourage employees increase their physical activity levels, we have promoted the app Jauntly. This is a walking app that uses photographs rather than maps to guide the user around scenic and interesting walks near by.

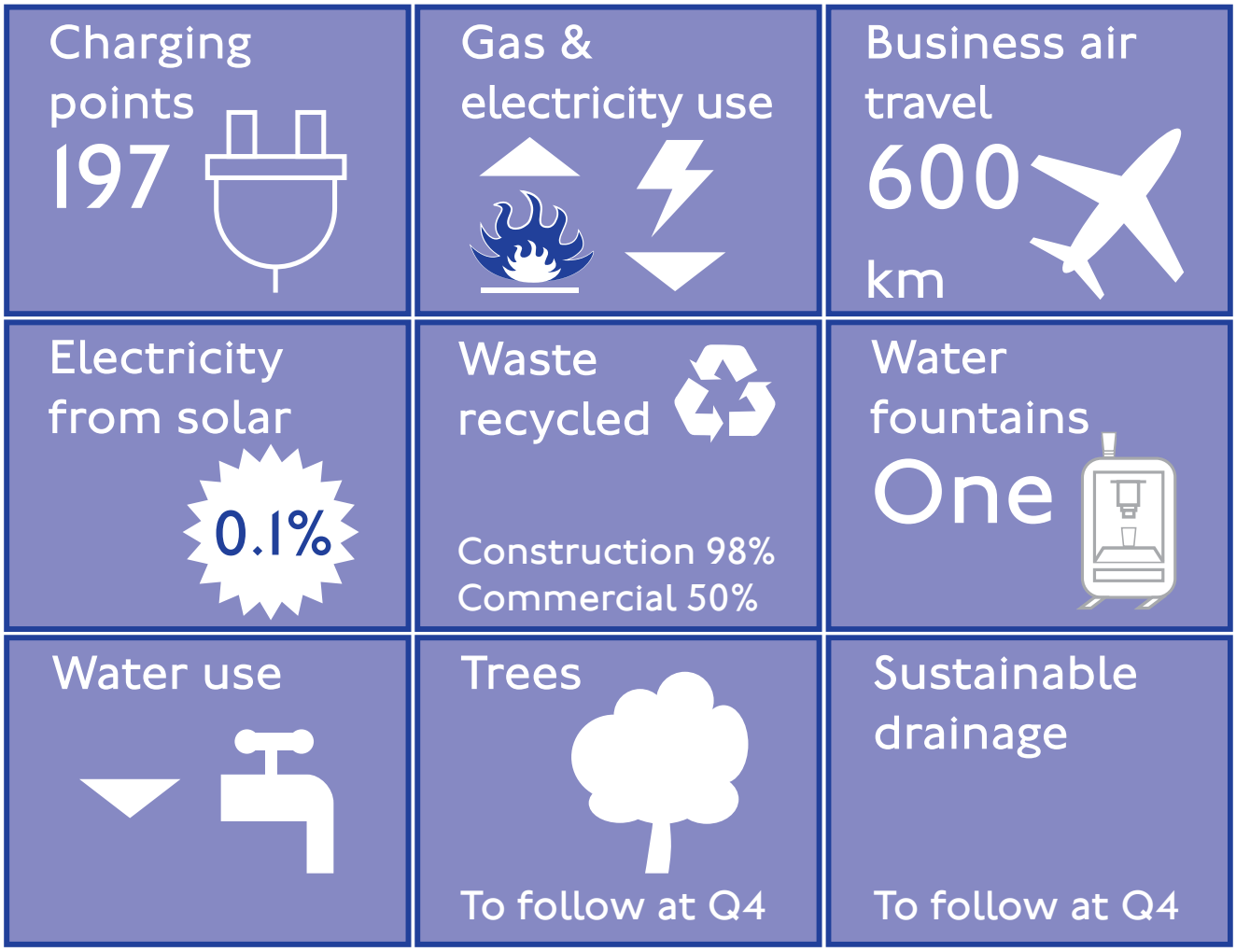
  Go Jauntly was selected as the winner of the Mayor's Active Travel Innovation Challenge last year. There are two TfL Walk London routes – The Thames Path and the Capital Ring which cover London reaching from Wimbledon Park to Greenwich.

London's streets will be clean and green



Environment

Scorecard



This year we are presenting more detailed environmental performance in this report. These are in line with GLA group key performance indicators from the London Environment Strategy 'leading by example' chapter. These are set out here for QI, where the data is available on a quarterly basis.

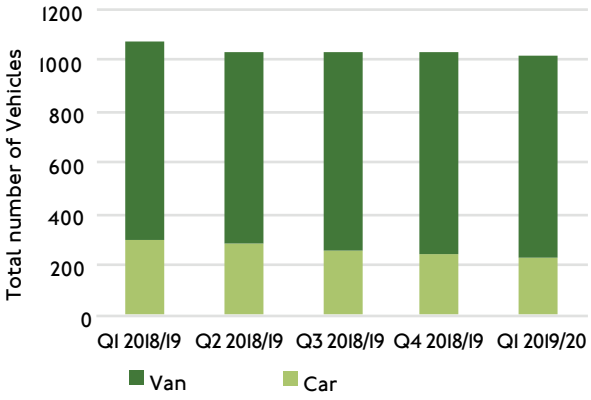
Where data is only available annually, we will report the collated annual figure in the Q4 report. We are developing TfL's updated Corporate Environment Strategy to take into account new Mayoral and other goals and will be presenting this to the Board SSHR Panel in November.

Euro VI buses

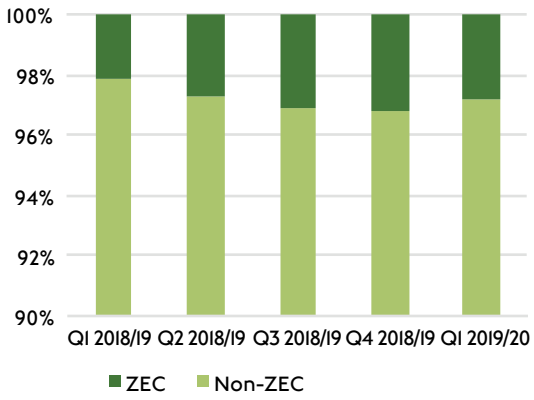
At the end of QI over 80 per cent of the bus fleet met a Euro VI emission standard or better, so we are on track to meet the target of 100 per cent complient by October 2030. We have 7,400 buses in the fleet that meet Euro VI emissions or better, this includes 155 pure electric buses and this number will continue to increase towards the end of the year. We are doing this by introducing new buses into the fleet and upgrading mid-life buses to meet Euro VI emissions.

Vehicle fleet - zero emissions

Total number of vehicles in fleet

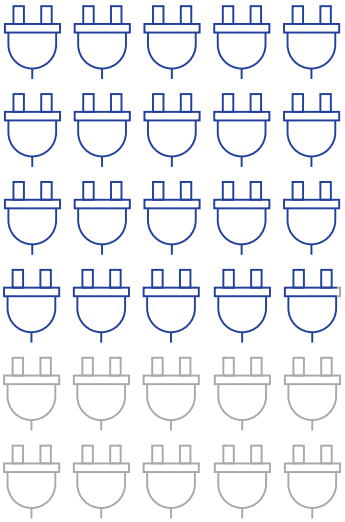


Proportion of vehicles meeting 2025 target



We seek to lease the most low emission solution for the types of vehicle class we are purchasing (eg car, van). By 2025, our target is that our vehicle fleet will be entirely zero emission capable (ZEC). The leases on our current vehicles all expire by 2025 and at that point we will replace them with ZEC vehicles if they are available in the class of vehicle.

Electric vehicle charging points



We have installed 197 rapid charge points and are on track to reach our target of 300 by the end of 2020.

The Electric Vehicle (EV) Infrastructure Taskforce Delivery Plan forecasts the level of EV infrastructure London needs, with wide ranges depending on how quickly the switch to EV takes place and the preference for charger type evolves:

- By 2020, using prudent EV uptake assumptions London will need around 200-400 rapid charge points and 3,400 to 4,700 slower charge points
- By 2025, with EV uptake in line with the MTS, this could rise to between 2,300 and 4,100 rapid chargers and 33,700 – 47,500 slower charge points (this is in line with the MTS).

The plan places a future focus on rapid charging hubs to support high mileage essential users. It recommends the next phase of delivery should prioritise at least five flagship rapid hubs, one in each sub region of London:

- The first at Baynard House in the City of London will contain 10 rapid chargers
- Progress on the east London hub in Greenwich is also continuing, and TfL is working with the private sector to bring forward a number of other potential hubs.

To improve the overall coverage of rapid charging, the plan also recommends rapids be prioritised for London's town centres. The private sector should adopt these approaches going forward, and TfL will also be doing so for the remainder of the 300 rapid chargers we will install by the end of 2020.

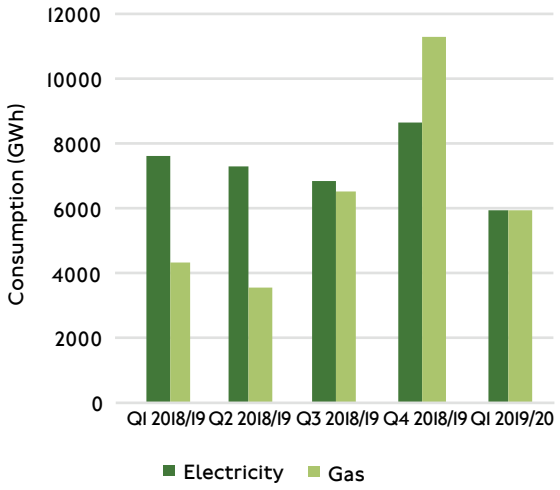
The plan recommends increasing the numbers of slower speed chargers and reducing their impact on the streetscape. The favoured model is both strategic and demand led, to ensure they are placed where they are needed most, and there is a good spread across London.

The plan contains a set of eight follow-on work streams, including:

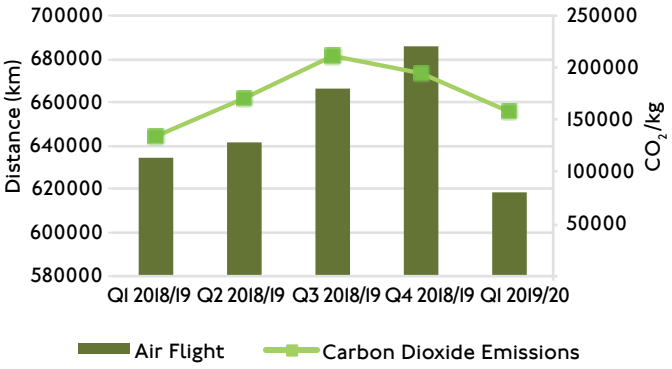
- Setting up a pan London coordination body to facilitate installation, led by London Councils
- An online tool to identify energy constraints, which has now been released by UKPN

The launch of the plan in June stimulated interest from the private sector, and we have been talking to private sector bodies about supporting their commitment to EV charging in London.

Gas and electricity use (GWh)



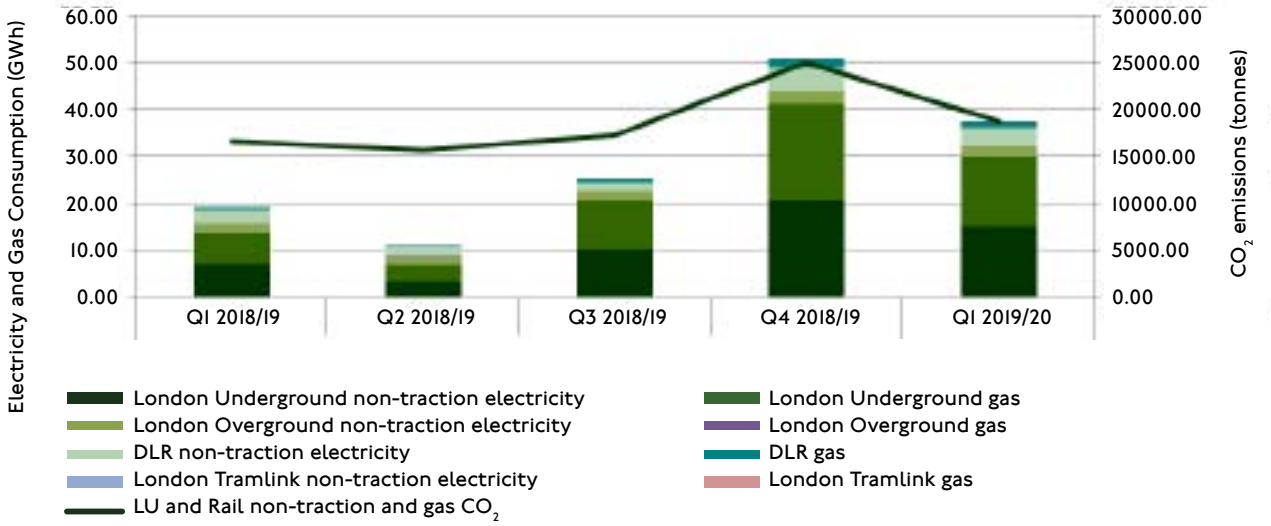
Business air travel



We are undertaking work to develop the best approach to meeting the ambition to supply our rail services with zero carbon energy, both through energy efficiency, onsite generation and procurement of renewable energy.
We have mapped the potential for solar generation on our rooftops and undertaken assessments of high potential land holdings for generation. We have also conducted an early market engagement exercise to better understand potential opportunities for connecting our assets to local sources of low carbon electricity. We are working with the GLA to explore opportunities for procurement of low carbon energy through Power Purchase Agreements (PPAs).

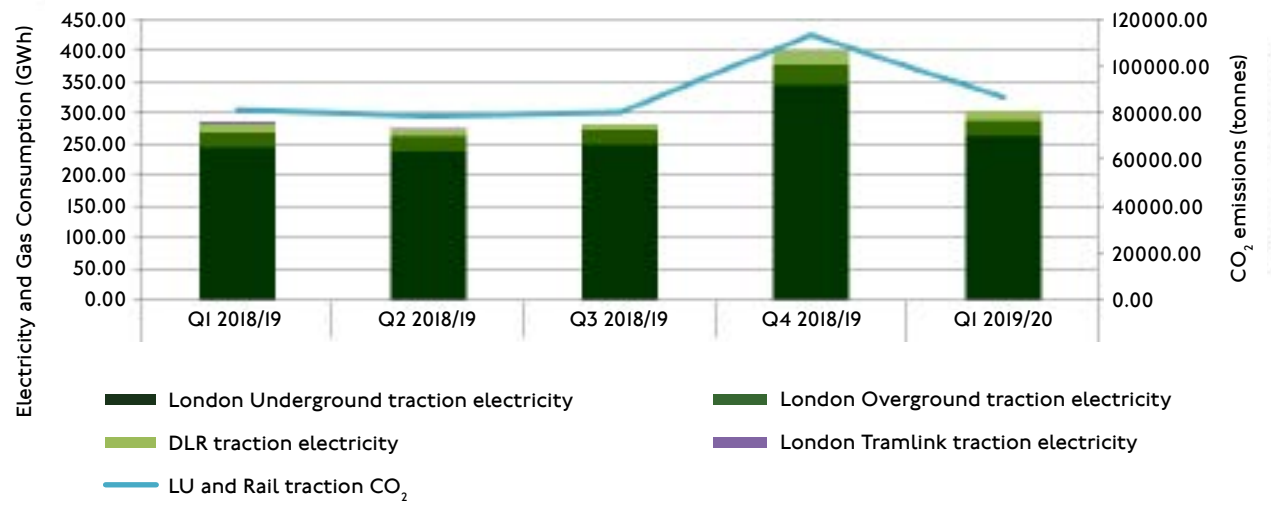
TfL staff undertake work abroad for a number of reasons, such as consultancy, researching suppliers and assets in use in other transport organisations or speaking at industry fora. We have a clear process for approving such travel and monitoring it.

Non-traction electricity and gas use (GWh) - past five quarters



Our use of non-traction electricity decreased by four per cent to 51.5 GWh compared to the same quarter in 2018/19. LU is responsible for the majority of consumption, although it used 4.4 per cent less than Q1 last year. Gas usage was up 16.7 per cent compared to Q1 in 2018/19.

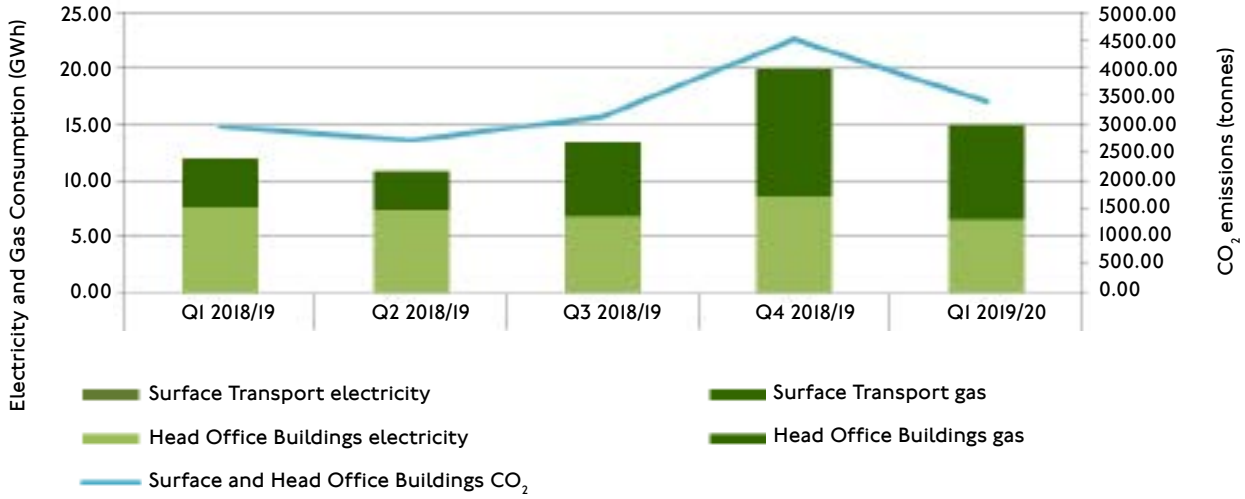
Traction electricity use (GWh) - past five quarters



Our use of traction energy decreased by 0.7 per cent to 281 GWh. LU is the biggest consumer although it decreased 0.7 per centcompared to the same quarterlast year. For London Overground, there was an 1.9 per cent increase. DLR lowered consumption by 3.9 per cent.

Total CO_2 emmisions from rail traction energy were 72,836 tonnes, an improvement of 10.2 per cent compared to Q1 last year.

Surface Transport and Head Office Gas and Electricity Consumption (GWh)



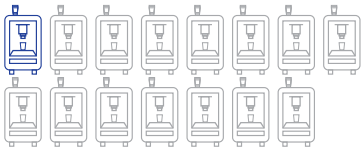
Within our head office buildings, we used 5.93 GWh of gas, up from 4.35 GWh in the same quarter last year. For electricity, we saw a reduction of four per cent in usage. Carbon emissions have decreased by 25.4 per cent compared to the same quarter last year.

Our energy strategy sets out our overarching approach to reducing CO_2 emissions from our operations. This contributes to the following four Mayoral ambitions set out in the MTS and LES:

- The TfL bus fleet to emit zero exhaust emissions by 2037
- All cars in GLA group support fleets being zero emission capable by 2025.
- Aim for all TfL-controlled rail services to be zero carbon by 2030.

Electricity generated on site from solar (capacity installed, electricity generated, % electrical demand met)	57,741 kWh
Percentage of electricity demand sourced from renewable energy (own generation and procured)	0.19% generated onsite 0% procured

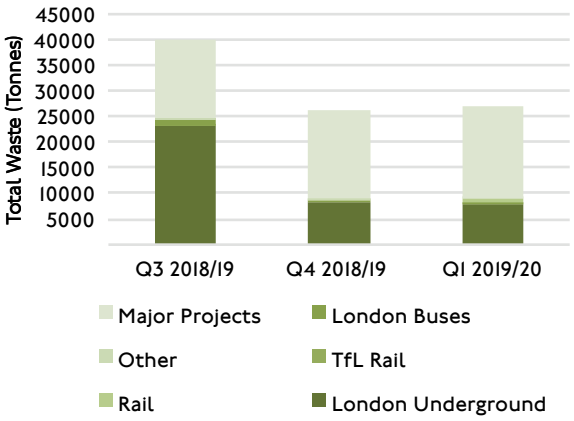
Water fountains



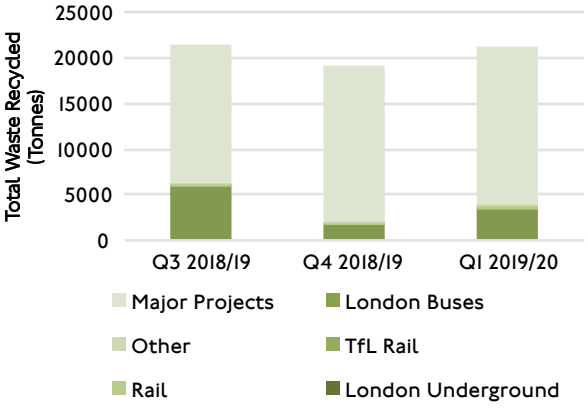
We are continuing our work to support the Mayor's goal for water fountain installation and increasing the provision of water to customers via the Refill London scheme. We are currently working on 15 sites for potential installation, working in conjunction with Thames Water.

Waste

Waste recycled by mode (tonnes)



Waste to landfill by mode



Area	Q1 incinerated	Q1 landfill
London Underground	100%	0%
TfL Rail	100%	0%
London Buses	100%	0%
Rail	99%	1%
Other	100%	0%

Approximately 90 per cent of our waste is construction, demolition and excavation waste from construction projects, 98 per cent of which was re-used or recycled in 2018/19. Of our commercial and industrial (C&I) waste, 50 per cent is recycled and and the remainder is sent to one of London's energy from waste plants. Used Metro newspapers are a major C&I waste stream for TfL. An improvement plan is being developed to maximise the use of recycling facilities at London Underground terminal stations.

We are working on implementing the single use plastics reduction plan that was finalised last summer. The plan includes plastic packaging reduction requirements in key contracts, such as head office catering, stationery and consumables. We will also replace single use plastic bottles with reusable bottles at key maintenance depot locations and issue all staff in LU Track Delivery with reusable bottles.

During the Quarter, our Commercial, Health, Safety & Environment and Asset Operations teams have been working with personal protective equipment (PPE) supplier, Hayley Rail to drive waste reduction. Together, they've come up with a clever idea of reusing a new style bump cap and its other cover.

Previously the old bump cap was disposed of as soon as it was dirty. However with the new style, we will see a reduction in waste going to landfill sites, as well as a reduction in pollution and the use of raw materials. The new cap covers can be washed at 60 degrees Celsius which kills all bacteria. The plastic shells are then disinfected and a new comfort liner is fitted. Following a thorough quality and safety check, the caps are returned to the vending machine ready for use. Annually, this initiative is set to save us approximately £50,000 in costs, together with a 680kg reduction in landfill waste.

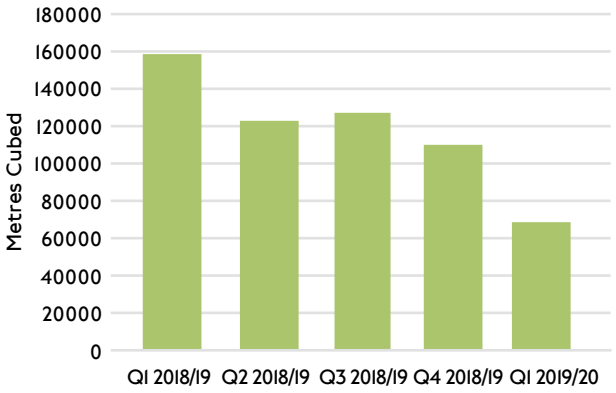
Data for DLR, Dail-a-Ride, London Overground, TfL Rail and Major Projects has been included where possible. Currently, these areas do not report on waste incinerated vs waste sent to landfill.

The split is as follows:
London Underground
TfL Rail: Crossrail and TfL Rail
London Buses
Rail: DLR, London Overground, Trams
Other: Head Offices, Dial-a-Ride
Major Projects: MPD and R&E

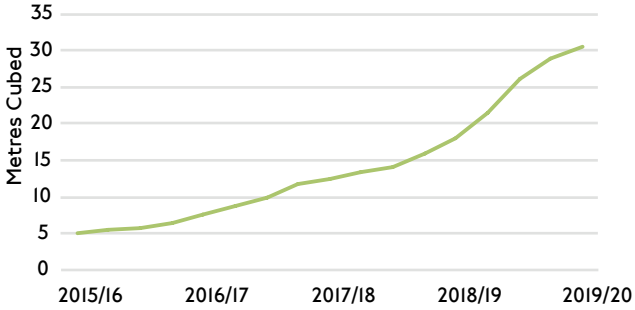
Head Office P3 waste data is outstanding, as is Dial-a-Ride

Water use

Past five quarters



Moving annual average



This data is included for the first time. We are continuing to develop our monitoring of water management and will provide further information in future reports.

Green infrastructure, biodiversity and trees

The MTS and the LES aim to deliver biodiversity net gain as part of transport schemes. Biodiversity net gain is being embedded into our project development and management processes. Training has also been provided to staff on how to use the biodiversity net gain project toolkit, as well as the biodiversity baseline data layer on our GIS systems.

After several years of planting more than 1,000 trees a year, the last two planting seasons have not been as successful. We now have a lot of work to do to make up for lost progress. We are developing a plan for planting 1,000 trees during the next tree planting season and will extend that plan to make sure we reach our overall Mayor's Transport Strategy target of a one per cent year-on-year increase in tree numbers on our roads to 2025. We will report on progress annually, in Quarter 4.

We are also working to improve monitoring of tree planting and installation of sustainable drainage systems (SuDS) in support of the MTS target for an additional effective surface area of 50,000m^2 to first drain into SuDS. We are working to incorporate SuDS into the delivery of improvement works on the TLRN, as well as encouraging boroughs to deliver via Local Implementation Plans (LIPs) and Liveable Neighbourhoods. We will report on M3 draining into SuDS as they are installed.

Climate change adaptation and resilience

Climate change is a strategic risk for TfL, with major hazards including overheating, flooding, and water shortages. Impacts range from infrastructure damage (e.g. high temperatures can cause damage to old signal systems, and flooding can destabilise embankments), with consequent impacts on performance. There are also safety implications for our customers (e.g. fainting on hot trains and slipping in wet weather).

We have established and chair the Transport Adaptation Steering Group, which brings together stakeholders (such as Network Rail and Highways England) and experts (such as the London Climate Change Partnership) to understand how we can address the issue of climate change adaptation in the transport sector.

In addition, we have set up a research programme with a range of academic institutions to develop a baseline of how current severe weather events (flooding and heatwaves) affect our operations (LU and TLRN). For example, a recent study identified a correlation between LU delay frequencies and ambient air temperature, with delays increasing at higher temperatures.

Using this information, the newly released 2018 UK Climate Projections, and the expertise of other transport sector partners, we will be better able to prepare for (adaptation) and recover quickly from (resilience) the likely impacts of future climate change. A preliminary assessment of suitable climate change adaptation indicators has been conducted, concluding that there is a need for an annual adaptation performance report.

Environment

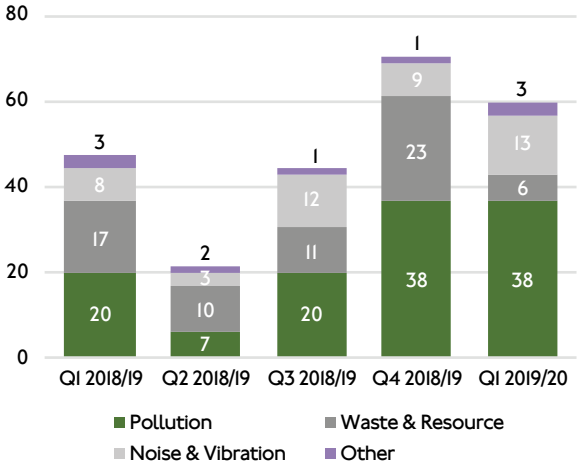
Environmental incidents

Streets	0
Buses	0
London Underground	41
Rail	6
Major projects	13
Total	60

Top causes of environmental incidents (%)

Pollution	63
Waste & resource	10
Noise & vibration	22
Other	5

Environmental incidents - past five quarters



There were 60 incidents in Q1, an increase of 25 per cent on last year, when there were 48. These were all minor incidents, with low or no impact, and so are investigated locally, for example, when the wrong waste type is observed being put in the wrong receptacle. We encourage full reporting of all incidents regardless of scale.

Environment

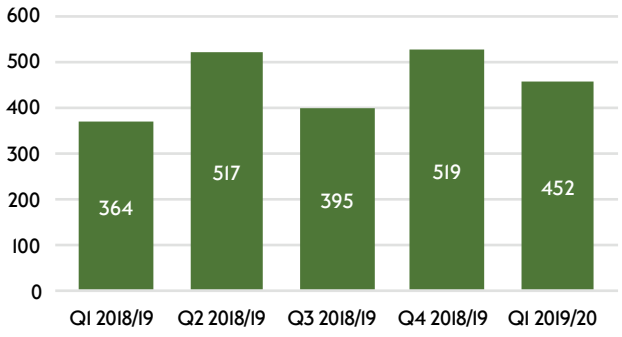
Top causes of environmental complaints (%)

Smell / Cleanliness	24
Operational noise	23
Graffiti / Vandalism / Waste / Litter	21
Engineering / Work noise	17

Top causes of environmental incidents (%)

Streets	7
Buses	38
London Underground	33
Rail	19
Major projects	0
Other	2

Environmental complaints



Environment-related complaints have increased 24 per cent compared to the same quarter last year.

This has been driven by a rise in complaints related to smell / cleanliness, operational noise associated with LU; and vandalism/ waste/litter/graffiti and air pollution associated with bus operations.

On our rail networks, complaints relating to operational noise and smell/cleanliness have increased.

The main drivers for this are:

- Bus complaints increased by 12 per cent; vandalism/graffiti/ waste/ litter and air pollution complaints have more than doubled since Q1 2018/19
- LU complaints increased by 35 per cent smell/cleanliness increased by 250 per cent, and operational noise increased by 56 per cent
- Rail complaints increased by 65 per cent; operational noise complaints increased by 65 per cent due to five Crossrail complaints, Crossrail complaints started to be counted by TfL a year ago. There was an increase of 8 Overground complaints. Construction works noise increased 333 per cent due to 28 Crossrail complaints and 8 tram complaints.

Did we deliver our planned improvements?

- Improve Monitoring of Circular Economy and Waste Data
  This year we are presenting more detailed environmental performance in this report. These are in line with GLA group key performance indicators from the London Environment Strategy 'leading by example' chapter. These are set out here for Quarter 1, where the data is available on a quarterly basis. Where data is only available annually, we will report the collated annual figure in the Quarter 4 report. We are developing TfL's updated Corporate Environment Strategy to take into account new Mayoral and other goals and will be presenting this to the Board SSHR Panel in November
- World Environment Day "Beat Air Pollution"
  In support of World Environment Day on 5 June presentations were made across TfL to highlight the problem of air pollution and explain what TfL is doing to help combat this major problem.

  Each World Environment Day is organised around a theme that focuses attention on a particularly pressing environmental concern. The theme for 2019, "Beat Air Pollution," is a call to action to combat this global crisis. This year's topic invited everyone to consider how we can change our everyday lives to reduce the amount of air pollution we produce, and thwart its contribution to global warming and its effects on our own health
- Ultra Low Emission Zone
  The central London Ultra Low Emission Zone (ULEZ) came into operation on 8 April 2019. Monitoring data has already shown a steady increase in the proportion of ULEZ compliant vehicles entering the Congestion Charging Zone since the Mayor approved the scheme in February 2017. Initial monitoring results since the scheme has gone live indicate that over 70 per cent of vehicles entering the zone are now compliant with the scheme and the aim is that at least 80 per cent of vehicles will be compliant by the end of the first year
- Low Emission Bus Zones
  The Low Emission Bus Zones (LEBZs) are being delivered in areas where Londoners are exposed to some of the highest levels of nitrogen dioxide (NO2) pollution.

  In April we delivered a further three LEBZs. The three zones are in Lewisham, Stratford and Edmonton, covering more than 1,330 buses across 79 different bus routes. This takes the total number of clean buses introduced as a result of the LEBZs to more than 3,000. We now have 10 LEBZs in areas across London.

Our plans for next quarter

Continue to upgrade buses along the final two LEBZs, which are Chiswick High Road to Kensington High Street and Uxbridge Road to Shepherds Bush, which will be ready for launch by the end of the year. Over 1,000 buses operating along these final two LEBZs will meet Euro VI emissions or better
Prepare for the Low Emission Zone (LEZ) standards to be strengthened for heavy vehicles in October 2020, and the ULEZ to be expanded to the North and South Circular Roads in October 2021
Continue to roll out zero emission buses to meet the target of a fully zero emission fleet by 2037


2242097
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progress...
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Regulatory investigation and enforcement update

In January 2019, the Environment Agency (EA) gave notice of its intention to impose a Compliance Notice on London Underground for breach of The Environmental Protection (Disposal of Polychlorinated Biphenyl and other Dangerous Substances) (England and Wales) Regulations 2000. The Compliance Notice proposed will require London Underground to ensure that all locations on the network are free of polychlorinated biphenyls (PCBs), the substances used to stop oils breaking down, by the end of 2023.

London Underground has programmes in place to comply with the proposed Compliance Notice. The Environment Agency has not yet issued the Compliance Notice to London Underground, but we are already working to eliminate all suspected polychlorinated biphenyls from the network. Our 2019 Registration of PCBs on our network was submitted in July and updates on our progress with disposing of PCBs will be provided to the EA every three months.

Audit conclusions

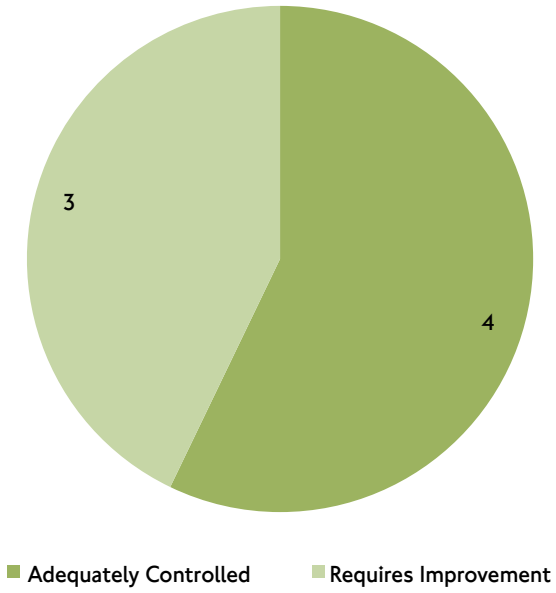
Q	Strategic Risk	Audit No.	Audit Title	Conclusion
Q1	Operational reliability	I9 707	BCV/SSL IRSE Licensing	Adequately Controlled
Q1	Achieving safety outcomes	I8 758	LU Platform Train Interface Programme	Adequately Controlled
Q1	Operational reliability	I9 704	Cleshar Management of the LO Fault Report Centre	Adequately Controlled
Q1	Operational reliability	I9 701	LU Wheelset Management	Adequately Controlled
Q1	Achieving safety outcomes	I9 765	Consultancy: LU Bulding Control and Sign Off	Consultancy
Q1	Financial sustainability	I8 804	PCI Victoria Coach Station	memo
Q1	Achieving safety outcomes	I8 807	DLR HSE Management System	memo
Q1	Financial sustainability	I8 801	PCI Bus Stop Closures	memo
Q1	Achieving safety outcomes	I9 700	LU Management of Legionella Risk	Requires Improvement
Q1	Achieving safety outcomes	I8 725	Management of Asbestos in Surface Transport	Requires Improvement
Q1	Achieving safety outcomes	I9 767	Trams Infrastructure Competence Management System	Requires Improvement

A total of 11 safety and quality related audits were conducted in quarter 1.

Three reports were concluded as 'requires improvement' and four reports were concluded as 'adequately controlled'. Four assurance assignments provided advisory memorandums which are not given a conclusion.

1. The audit of LUs management of Legionella risk was concluded as 'requires improvement' as the arrangements and information management systems in place were not fully compliant with the HSE Approved Code of Practice. There were also elements of over control leading to unnecessary costs. An investigation had highlighted that the contract management and assurance systems needed strengthening, the audit to explore these issues further was a recommendation of the Formal Investigation Report (FIR). It was noted that a new information management system is due to be implemented which should address the issues noted.
2. The audit of the TfL Trams Infrastructure Competence Management System was concluded as 'requires improvement'. Improvements to the Competence Management System are either underway or have been proposed. The management team are committed to the actions and have commissioned resourcing review to establish what is required to deliver these and other related actions.
3. The audit of ST management of asbestos was concluded as 'requires improvement'. Although full compliance with the regulations had not yet been reached, work towards this has made significant progress in the past year and is planned to be completed in quarter 2.

4. An Internal Audit memo issued in 2017 highlighted legislative non-compliance, this audit verified the management team have been successfully working to address the issues raised and some of the equipment used when working with electrical systems was not adequately inspected or maintained. In response, improvements have been made in the documentation and assessment of risk for live working for our signals maintenance team and in the tracking of training records.



The annual review of the DLR HSE management system was undertaken internally by General Counsel Risk and Assurance for the first time, providing a substantial saving compared with previous external suppliers. The review addressed four scope items: risk from third party developments, incident investigation, management of safety actions and fatigue. Eleven recommendations were made regarding compliance with ORR fatigue guidance and nine recommendations were made regarding the other three scope items.

More people will travel actively in London

Healthy streets

Healthy streets check for designers

The Healthy Streets Check for Designers (HSCD) is a tool that reviews whether proposed changes to the street will result in improvements against the 10 Healthy Streets Indicators. It aids designers in aligning to the Healthy Streets Approach. The tool provides a score for both the existing street layout and proposed design, with the uplift demonstrating the scale of the improvement of the street for people's health.

The Check was introduced in 2018/19 as an interim active travel performance metric on the TfL Scorecard, with a target of 10 per cent average uplift across all eligible schemes. While the HSCD tool was being embedded in 2018/19 only those eligible projects with an estimated final cost in excess of £200k were included as part of the Check.

The scope of the HSCD has been expanded in 2019/20 to include all TLRN and Liveable Neighborhood projects within the Healthy Streets portfolio regardless of estimated financial cost, and which make a material change to the street environment. This scope was changed in 2019/20 with the aim of boosting the number of schemes eligible to complete HSCD.

At the end of Q1 2019/20 10 eligible schemes completed a HSCD at Detailed Design. The average uplift across the 10 projects was 15 per cent points, which exceeded the scorecard target of 10. Over the same period for 2018/19 only two eligible schemes had completed a HSCD.

TfL will continue to work to ensure schemes in subsequent quarters achieve the highest uplift scores possible to facilitate the largest improvements to London's streets.

Number of Healthy Streets Checks undertaken on the TfL Road Network

	Q1 2019/20	Year end target
Number of schemes with a completed Healthy Streets Check for Designers at Detailed Design	10	N/A
Average percentage point uplift across schemes	15	10

Appendix: Sandilands investigation recommendations applicable to TfL

Recommendation	Progress to date
UK tram operators, owners and infrastructure managers should conduct a systematic review of operational risks and control measures associated with the design, maintenance and operation of tramways. [RAIB recommendation 2. Links with RAIB Recommendation 1, 10, and TfL Recommendation 5]	Complete: Together with Tram Operations Ltd (TOL) we are represented on the UK Tram Industry Sandilands Sub Committee, established to consider the RAIB findings and take action on behalf of the UK tram industry. Our (together with TOL) review of route risk assessments and our network risk model has been shared with the wider UK tram industry. The industry has reviewed all risk assessments within the industry to agree a standard approach, a standard model has been developed and verified. it is now being rolled out. In support of the model we have also agreed the arrangements to collect industry incident and injury data. National roll out for the risk model and data model In Q1 there were 19 vulnerable road users were killed or seriously injured in collisions involving buses, a 21 per cent improvement from last year. We presented an overview and findings of Risk Model work to Rail Safety and Standards Board Risk Management Forum in June 2018. The model was revised again in March 2019.
UK tram operators, owners and infrastructure managers should work together to review, develop, and install suitable measures to automatically reduce tram speeds if they approach higher risk locations at speeds which could result in derailment or overturning. [RAIB recommendation 3. Links with TfL recommendation 2]	In Progress: A contract was awarded to Engineering Support Group in December 2018. The new system will automatically bring a moving tram to a controlled stop if it were to exceed the speed limit (by a safe margin) at a designated location. It will also alert the operations control centre. The system will initially be configured to priority locations as suggested by the RAIB recommendation. It also has the flexibility to be introduced elsewhere on the tram network. We remain on target for the system to be installed and in operation by the end of 2019. (This includes a period of training and familiarisation with tram drivers ahead of it becoming fully operational.) TOL are an active stakeholder in this. The Feasibility and scoping work for this system has been shared with other tram owners and operators to assist in the development of a programme for installing similar suitable systems to their networks.

Recommendation	Progress to date
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. [RAIB recommendation 4]	In progress: Working closely with TOL, LT has procured and commissioned the 'Seeing Machine Guardian' driver protection system fleet wide. This system uses proven facial movement technology to monitor driver fatigue and distraction. The system was fully installed across the LT fleet in October 2017. An additional feature of the Guardian system is that it is programmed to alert drivers if the maximum speed goes above 70kph. TOL were closely involved in the selection and implementation of this system and played the major role in securing driver support. LT and TOL have already hosted several delegations, including UKTram and others, to demonstrate the technology in operation. While the systems does not apply the brakes automatically, the Office of Rail and Road (ORR) recognses the safety benefits the system has brought to London Trams. This system is designed to detect driver inattentiveness and provide an alert, but does not, itself, apply the brakes, as suggested as an option in the recommendation. As detailed in recommendation three, an automatic braking system has been procured and will be installed by the end of 2019 as a separate measure. Research work being undertaken by UK Trams is exploring what an appropriate automatic response would be if a low level of driver attentiveness is detected, such as the application of brakes. TfL will review this research to ensure the system in use is compatible with the outcomes
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 required by drivers on the approach to high risk locations.	Complete: We undertook a comprehensive review of tram speeds and speed signage across its network. As a result the following measures were put in place by September 2017. TOL are an active and engaged stakeholder on this initiative: 1. The maximum tram speed on the network was reduced by 10kph, from 80kph to 70kph. The effect is that the potential for coasting in high speed areas has been removed, and that continual speed management is required in these low workload areas so increasing driver alertness. 2. Additional step down speed signage was implemented in all locations where speeds reduced by more than 20kph, enhancing driver visual cueing and orientation. 3. Where speed signs are located immediately in advance of higher risk locations, e.g. a tram stop or a curve with low approach visibility, the sign has been enhanced with the addition high visibility outer border as an additional visual cue to drivers of an approaching hazard. iTram We will also implement iTram to provide audible in-cab over speed alerts. iTram is a performance monitoring tool that as well as driving safety improvements by trend analysis of tram speeds, also utilises GPS technology to provide over speed warnings to drivers at all points across the network. It is therefore an enhancement on the Guardian system which can only alert drivers if they exceed the maximum speed limit. Fitment across the fleet will be completed by December 2019

Recommendation	Progress to date
[RAIB recommendation 5. Links to TfL Recommendation 1]	Review of Visual Cueing Together with TOL we have completed a comprehensive Route Hazard Analysis. The conclusion is that the already completed installation of additional speed signage work improves driver visual cueing on the network. Conceptual designs for enhanced visual cueing in Sandilands tunnel are under TOL driver consultation. Tunnel Lighting Post the Sandilands incident we installed additional temporary lighting on the approach to the Sandilands tunnel, while our road tunnel lighting experts developed a permanent solution. The new design will adopt best practice from the automotive industry to reduce the impact of glare on driver's eyes both when entering and exiting the tunnel. Work is expected to be complete on the improved tunnel lighting by December 2019. Installation of highways type road studs ("cats eyes") as a sleeper mounted orientation aid within the Sandilands tunnel was completed in May 2019. The studs are deployed on the 'Up' road only to provide differentiation between directions of travel. They are also configured to provide visual orientation between the individual tunnel sections We are also trialling illuminated warning signs, similar to those used on roads to warn drivers their speed is above the limit. The effectiveness of these signs will be evaluated in summer 2019 and the feedback will be shared with the UK tram industry.
UK tram operators and owners should, in consultation with appropriate tram manufacturers and other European tramways, review existing research and, if necessary, undertake further research to identify means of improving the customer containment provided by tram windows and doors. [RAIB recommendation 6. Links to TfL Recommendation 8]	Complete: We commissioned the manufacture and testing of several prototype windows that could provide an appropriate level of additional containment. These prototypes were assessed against the conditions likely to have been encountered during the Sandilands incident, and taking into account any affect they may have on ease of access for the emergency services. We concluded that mainline rail crash worthiness standard GM/RT2100 is more likely to offer protection against the conditions experienced during the Sandilands event. Strengthening film on top of the existing tempered glass was selected as the immediate solution to strengthen glazing on trams. Following the extensive testing with safety experts and a new higher specification film that is 75% thicker (from 100microns to 175microns) has been fitted to all doors and windows to improve containment. We are investigating the practicalities of modifying tram doors and we will consider the recommendations made by the RAIB when designing new vehicles in the future.
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. [RAIB recommendation 7]	In progress: In conjunction with industry experts, we have formulated a Technical Specification for the retrofitting emergency lighting to its fleet. The system will be fully autonomous, and will operate independently of the trams battery system in the event of an emergency. Role out of the system is planned for autumn 2019. TOL are an active and engaged stakeholder on this initiative.

Recommendation	Progress to date
UK tram operators and owners should review options for enabling the rapid evacuation of a tram which is lying on its side after an accident. [RAIB recommendation 8]	In progress: We continue to work with tram operators and tram manufacturers to identify and evaluate options to achieve this objective.
TOL and LT should commission an independent review of its process for assessing risk associated with the operation of trams. [RAIB recommendation 10. Links with RAIB recommendation 2]	Complete: The network risk model and route risk assessments have been reviewed and updated. They have been shared with the wider UK tram industry and we also presented an overview and findings of Risk Model work to Rail Safety and Standards Board Risk Management Forum in June 2018. Work has also been completed on our tram crossing risk assessments for Croydon town centre. A joint management process for the embedment of the models has been developed. They remain under regular review. The most recent review of the LT Risk Model was completed in March 2019. The industry is reviewing all risk assessments within the industry to agree a standard approach. The LT/TOL risk assessments will be further reviewed and revised in line with this approach.
TOL should review and, where necessary, improve the management of fatigue risk affecting its tram drivers with reference to the ORR's good practice guidance. [RAIB recommendation 11]	In progress: TOL are implementing a safety improvement plan designed to address the intent of this recommendation through their own internal safety governance arrangements.
TOL should commission an external organisation to review, the way that it learns from operational experience. [RAIB recommendation 12]	Complete: TOL have implemented a 'Just Culture' Programme designed to address the intent of this recommendation through their own internal safety governance arrangements.
TOL and LT should review and improve the process for managing public and employee comments that indicate a possible safety risk. [RAIB recommendation 13]	Complete: We have reviewed our customer complaints procedure and how employees report issues to us and implemented improvements to ensure that any safety issue raised is dealt with efficiently and thoroughly across the TfL network.
TOL and LT should review and improve their processes for inspecting and maintaining on-tram CCTV equipment to greatly reduce the likelihood of recorded images being unavailable for accident and incident investigation. This recommendation may apply to other UK tram operators. [RAIB recommendation 14]	Complete: All LT Bombardier fleet has been fitted with new CCTV image recorders. CCTV health checkers which actively monitor the status of recording units and identify faults. The CCTV recording equipment on all Bombardier trams (type involved in Sandilands) was replaced and upgraded to digital shortly after the overturning. The equipment on Stadler trams, which make up the remainder of the fleet, had adequate functionality. Further work to upgrade CCTV on the wider fleet will be completed by May 2019.

Recommendation	Progress to date
TOL and LT should review and revise where required existing tram maintenance and testing documentation to take account of experienced gained, and modifications made, since the trams were brought into operational service. [RAIB recommendation 15]	In progress: LT has undertaken a comprehensive review of its written standards, maintenance processes and identified quality deficiencies. LT has appointed an independent entity to author new written standards, maintenance processes and forms addressing all quality gaps. This process will be in two phases. Sixteen critically prioritised standards and associated documents have been delivered in the first phase. The remaining standards and processes will be addressed through our routine arrangements for the maintenance of the management system.
Review available driver cues in relation to braking points on approaching a curved section of the tramway. [TfL recommendation 1. Links to RAIB recommendation 5]	Complete: Overall network top speed has been reduced from 80kph to 70kph. Additional 70kph signs have been provided to aid driver awareness of the permitted maximum speed. A design and signal sighting exercise has been concluded and the provision of additional step down speed signage to aid driver speed awareness and visual cueing is complete. Additional visibility signs have also been provided, which will heighten driver speed awareness in high risk areas.
Review available driver cues in relation to braking points on approaching a curved section of the tramway. [TfL recommendation 1. Links to RAIB recommendation 5]	Complete: Overall network top speed has been reduced from 80kph to 70kph. Additional 70kph signs have been provided to aid driver awareness of the permitted maximum speed. A design and signal sighting exercise has been concluded and the provision of additional step down speed signage to aid driver speed awareness and visual cueing is complete. Additional visibility signs have also been provided, which will heighten driver speed awareness in high risk areas.
Review of arrangements for the monitoring and management of speeding. [TfL recommendation 2. Links to RAIB recommendation 3]	LT has commissioned the installation and commissioning of the 'iTram' system, which will provide driver over-speed alerts network wide. iTram will also provide oncoming hazard awareness to drivers of high risk areas. The system has been installed on all 22 Bombardier trams and the roll-out on Stadler trams began in April 2019.
Review of traction brake controller (TBC) driver's safety device design. [TfL recommendation 3]	Complete: LT has procured and commissioned the 'Seeing Machine Guardian' driver protection system fleet wide. This system provides proven driver fatigue and distraction management via facial recognition technology. It was fully installed across the London Trams fleet in October 2017. ORR recognises the safety benefits that the system has brought to London Trams.

August 2019

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Safety, Sustainability and Human Resource Panel

Date: **4 September 2019**

Item: **Bus Safety Programme**

This paper will be considered in public

1 Summary

1.1 This paper provides an update on the progress of the Bus Safety Programme and key future deliverables.

2 Recommendation

2.1 **The Panel is asked to note the paper.**

3 Bus Safety Programme Delivery Update

3.1 The Mayor and TfL have now adopted Vision Zero for London, with a target of zero deaths or serious injuries from road collisions by 2041.

3.2 Within Bus Operations we have even more ambitious targets:

(a) 70 per cent reduction in the number of people killed or seriously injured in, or by, buses by 2022 (against 2005-09 baseline)

(b) No one killed in, or by, a bus by 2030.

3.3 The Bus Safety Programme was launched in February 2016, with the aim of reducing the number of people killed or seriously injured (KSI) on the bus network.

3.4 In 2018/19 the number of KSIs was down by 58.9 per cent from the 2005-09 baseline, meaning we are making good progress but it will still be challenging to achieve a 70 per cent reduction by 2022.

3.5 The Bus Safety Programme is aligned with the Vision Zero 'Safe Systems' approach which aims to ensure safe speeds, safe streets, safe behaviours and safe vehicles. Progress against each area is detailed below.

4 Safe Speeds

4.1 Intelligent Speed Assistance (ISA) technology, which ensures compliance with speed limits, is a key part of the Bus Safety Standard. ISA uses GPS-linked speed limit data to advise the driver of the current speed limit and automatically limit the speed of the vehicle as necessary. There are currently just over 800 ISA enabled buses in London with a further 300 expected by the end of the financial year which includes all new build vehicles from August 2019.

4.2 TfL had planned to roll out ISA across its existing bus fleet via the iBus 2 update. However, following market engagement as part of the iBus 2 project, it is not feasible to roll out ISA in this way to the entire fleet by 2022. In order to roll out ISA on as many buses as possible, as quickly as possible, we are seeking solutions directly with the bus manufacturers. We are also encouraging them to adapt the software on their existing models in order to activate ISA in a more expedient way than a third-party, off-the-shelf solution could achieve. This retrofit programme is planned to begin in the next financial year and will run until 2024.

5 Safe Streets

5.1 TfL has appointed Integrated Transport Planning Limited (ITP) to conduct research into pedestrian behaviour and risk management.

5.2 With input from behavioural psychology and transport planning specialists, ITP completed a literature review of existing research in the transport and cognitive behavioural fields. The literature review covered the impact of electronic device usage on pedestrian distraction and behaviour, as well as pedestrian risk management measures which have been trialled elsewhere.

5.3 Insights from the literature review were then used to help design on-street observational surveys at a range of locations in London, including bus stops and bus lanes (both regular and contraflow). Locations with comparable infrastructure but contrasting pedestrian casualty rates were included in the study, for example a bus lane with a low pedestrian casualty rate and one with a high rate. Data from the on-street observations is currently being analysed and will increase understanding of the nature and circumstances of risky pedestrian behaviours.

5.4 The identification of environmental and behavioural risk factors will then inform potential solutions including those that are physical (engineering responses that alter the physical layout of the street) and technological (changes or additions to street technology, including ground surfaces and signals equipment). From this list of options, preferred solutions will be identified via an evaluation of cost, effectiveness in terms of casualty reduction, and ease of interpretation and implementation.

6 Safe Behaviour: Bus Driver Training

6.1 Via a competitive procurement process in autumn 2018, TfL appointed Steps Drama to develop a safety training programme for London's bus drivers. Production of the course is complete and it is now being delivered to drivers. All 25,000+ bus drivers in London will receive the training over the next 18 months.

6.2 The training course uses innovative virtual reality technology, which is designed to make the course more engaging and impactful. Extensive filming took place in London so that participants in the training can experience, through this technology, a wide range of scenarios that drivers in London may encounter.

6.3 Part of the course focuses on improving drivers' hazard perception. The virtual reality technology gives participants a 360° view from the driver's seat as a series of recorded situations play out. In other scenarios, the training participant is put in the position of a vulnerable road user, such as a cyclist or motorcyclist. The aim is to increase drivers' awareness of what it is like to share road space with large vehicles like buses.

6.4 Other sections of the training emphasise the link between driver wellbeing and safety. Participants view a virtual reality film which is designed to provoke discussions on topics such as health, sleep and lifestyle, and how these can affect the safety of their driving.

6.5 Several operators have set up local working groups to collate and act upon safety-related feedback and issues raised during the delivery of the driver training course.

6.6 Initial feedback from the first drivers to receive the training has been very positive. 2,098 drivers had been trained by the end of July and 93 per cent of them have rated the course as good or excellent. When asked how useful they would find the learning from the course in their day job, 97 per cent of drivers rated it as between useful and extremely useful. In addition, 97 per cent would recommend Destination Zero to a colleague. TfL has appointed TRL Limited to independently evaluate the longer term impacts of the driver training.

7 Safe Behaviour: Fatigue Research and Management

Background

7.1 Driver fatigue is under researched and under reported, despite anecdotal evidence to suggest it is a problem across the transport industry (including freight as well as passenger transport).

7.2 At the February 2018 meeting between the Mayor of London, Unite the Union (Unite) and TfL, the Mayor asked TfL to consider commissioning an independent review of driver fatigue causes. In July 2017 the London Assembly Transport Committee had published a report, 'Driven to Distraction' which also raised concerns around bus driver fatigue.

7.3 In response to the above and Unite's work prior to this, which also highlighted the problem, in July 2018 TfL commissioned experts from Loughborough University and the Swedish Road and Transport Institute (VTI) to carry out an independent research study to establish the extent, nature and causes of fatigue amongst London bus drivers. The researchers were also asked to propose evidence-based solutions to reduce fatigue and the risk of associated incidents.

7.4 The world-leading research involved a driver survey, focus groups, interviews and an on-road study. The researchers also undertook wide-ranging consultation and discussions during their research including with directors of the bus operating companies and with Unite representatives. It was completed in May 2019 and the final report is attached as appendix 1. The report was published on TfL's website on 28 August 2019 and is also available at https://tfl.gov.uk/corporate/publications-and-reports/bus-safety-data/

7.5 The research found that bus drivers are exposed to a wide range of occupational and personal factors that increase their vulnerability to fatigue and concluded that bus driver fatigue in London is a risk that requires better management. The report proposes a range of solutions covering education, working conditions, schedules and rosters, open culture and health.

7.6 The report emphasises that there is no quick fix for reducing fatigue. A long-term commitment is needed, from the bus operating companies (at all levels) who employ and manage the drivers, the drivers themselves, the drivers' recognised trades union, TfL as well as regulatory bodies.

Work currently underway to mitigate bus driver fatigue

7.7 TfL and the bus operating companies were already working on a number of initiatives to address some of the risks highlighted by the report:

(a) All operating companies in London adhere to strict drivers' hours regulations and some already have controls in place to reduce fatigue risk. TfL assures these controls as well as actual hours worked.

(b) Many companies have agreements where the length of rostered shifts and working weeks are considerably less than maximum specified by the regulations.

(c) The new bus driver safety training course, Destination Zero, which will be delivered to all 25,000 drivers between May 2019 and October 2020, has a strong focus on driver wellbeing, health and sleep.

(d) Many bus operating companies are establishing their own working groups to respond to fatigue-related issues raised by drivers.

(e) Starting in September 2019, a 'Health Bus' will begin visiting bus garages to offer support and information to drivers on health-related issues, with a focus on fatigue. This is a joint initiative between TfL, the bus operators and Unite.

(f) We are committed to improving drivers' working conditions, including access to toilets, which the research found is strongly connected to driver stress and fatigue:

i. Since the Mayoral announcement on bus driver toilet facilities in February 2018, we have made facilities available on 43 priority routes during all operational hours.

ii. We are committed to continuing this programme and finding solutions for the remaining routes so that every London bus route has toilet facilities available to drivers throughout operational hours.

iii. We have increased the maintenance budget for driver toilets and are conducting a review to ensure that the maintenance and cleaning regime is as appropriate as possible.

Stakeholder engagement

7.8 Prior to setting up a forum to discuss the findings in the tripartite format, TfL set up an operator working group to better understand current practices and to work through issues that we could reasonably anticipate could arise from the report. The final report was shared with bus operators, Unite and key internal stakeholders in June.

7.9 Unite, representative bus operators and TfL have met twice in June to discuss the recommendations in the report and the ways in which we can work together to address the findings. A further meeting is planned for later in September.

Next steps

7.10 Further to the solutions identified in the report, as highlighted in section 7.5, we have identified priority actions to better manage bus driver fatigue risk.

(a) TfL wrote to all the London Bus operators with a copy of the final report and asked them to immediately begin work on developing a Fatigue Risk Management System (FRMS) and to respond by the end of July with an outline structure and an action plan to deliver this.

The FRMS needs to be specific to each company and will encompass many of the recommendations set out in the report. Specifically, it must promote a more open culture within bus operators. We expect operators' FRMSs to put in place measures to increase drivers' confidence to report fatigue, near misses and other safety concerns, and to increase operators' capability to use this information to identify and address root causes.

Within the FRMS, TfL will also require all operators to assess the fatigue risk associated with their rosters through:

i. review against good practice in roster design;

ii. use of a bio mathematical fatigue assessment tool; and

iii. consultation with or feedback from staff, including through operators working groups that include drivers.

TfL is now reviewing the responses from each operator to ensure they are on the right track with developing their full plans. Within 12 months there will be a requirement for an operator to have a robust fatigue risk management system in place before any new route contract is let. Discussions are ongoing as to what constitutes such a system, which may include TfL specifying the bio mathematical fatigue assessment tool to be used by all operators to evaluate rosters for fatigue risk. These discussions will include Unite as part of our regular tripartite meetings.

(b) A £0.5M TfL fatigue innovation fund will be launched for bus operators to bid into next year. This fund is intended not just for trialling new technology but to come up with innovative solutions to change the safety culture within bus garages and increase focus on driver health and well being. Unite will be involved in defining the fund and assessing operator bids

(c) TfL will introduce a Fatigue Key Performance Indicator for bus operators. This will track the percentage of managers within the bus operators who are trained in fatigue management. TfL will explore whether a course already exists that is appropriate for the bus industry for example from the HSE, or whether we need to develop something bespoke for our operators. If a suitable course already exists, this is something we look to begin rolling out by the end of the year. Driver representatives will also have the opportunity to receive this training.

(d) Operator Fatigue Working groups were set up prior to receipt of the final report to understand what operators are already doing and start the process of sharing best practice. This approach has proven successful in other areas of safety and these will continue.

(e) While progress has been made in reducing the frequency of drivers finishing work late (normally due to congestions or events), this is still an issue on some routes. We commit to further work with operators to reduce this, both through improved schedule planning, and also improving responsiveness to real time issues on the network.

(f) We will present an update with further timescales for delivery to the Panel at a future meeting ensuring the measures being implemented for bus drivers are aligned with TfL's wider fatigue management strategy being led by TfL HSE.

(g) As the findings of this report are of national relevance we are sharing a copy with the Department for Transport, The Traffic Commissioner, the Health and Safety Executive and the Confederation of Passenger Transport, and the wider transport industry in order to start a discussion on the potential for legislative change for all road transport.

8 Safe Vehicles: Bus Safety Innovation Challenge

8.1 In August 2017, we launched the Bus Safety Innovation Fund with the aim of trialling innovative safety products or solutions that could help reduce the number of people killed or seriously injured on the bus network. Six operators were successful and shared £500,000 of funding for eight projects.

8.2 There were mixed results from the Bus Safety Innovation Fund. Some trials were unsuccessful or did not produce robust enough results. Others were more successful, with one operator, Abellio, winning 'Most Innovative Transport Project' at the London Transport Awards for its trial of an advanced collision warning system, 'Mobileye', which alerts the driver to the presence of pedestrians and cyclists in close proximity to the bus.

8.3 In April 2019, we launched the Bus Safety Innovation Challenge. The Innovation Challenge is designed slightly differently to the Innovation Fund in order to avoid some of the issues which arose during the Innovation Fund process. Applications were submitted jointly by a bus operating company and the developer of the innovation.

8.4 All applications were assessed by a TfL panel and independent technical experts. The five successful applications are:

(a) fatigue monitoring tool (application submitted by Abellio and Datik);

(b) vulnerable road user intent prediction software (Arriva and Humanising Autonomy);

(c) video-based driver safety coaching programme (CT Plus and Lytx);

(d) lighting system to illuminate area by the side of buses (Metroline and JBDL); and

(e) pedestrian and cyclist detection and driver alert system (Stagecoach and Fusion).

8.5 TfL will support these projects by funding the independent analysis of the trials. The proposed test and evaluation procedures have been reviewed to ensure that the trials produce robust evidence of the effectiveness of the solutions in reducing casualties on the bus network.

9 Safe Vehicles: Bus Safety Standard

9.1 The first buses which meet all the 2019 requirements of the Bus Safety Standard (BSS) were delivered in August 2019.

9.2 In April 2019, TfL contracted Aecom to design and develop an 'urban bus sound' to be emitted via an Acoustic Vehicle Alerting System (AVAS) on quiet-running buses. The brief required a sound that was compliant with UN ECE regulation 138 and which would make a positive contribution to the London soundscape in the context of the Mayor of London's 'Healthy Streets' approach. Aecom engaged extensively with internal and external stakeholders, including accessibility and road user groups, to ensure these objectives were met. The sound is in the final stages of development and will be launched in the Autumn.

9.4 Blind spot mirrors are another of the key deliverables in the 2019 BSS specification. These will replace existing wing mirrors to improve drivers' indirect vision, particularly of areas where vulnerable road users are likely to be present and where they cannot currently be seen by the driver. We have identified solutions for fitting blind spot mirrors to every bus model, and are on track to have them installed across the entire bus fleet before the end of the financial year.

9.5 In future, blind spot mirrors will be replaced by a Camera Monitor System (CMS) as shown in the picture below, which removes the external mirrors and replaces them with digital screens inside the drivers' cab. CMS is not required under the BSS until 2021, but the first buses with it installed have recently been delivered to London operators. TfL is encouraged by this example of bus manufacturing companies developing and introducing new safety technology ahead of the required dates.

Metroline bus fitted with CMS

9.6 The 2019 BSS specification also requires a Pedal Indicator Light (PIL), which will show up on the dashboard to warn the driver that the accelerator is being pressed. The symbol for the PIL meets existing ISO standards and was designed based on feedback from drivers. This is the first of a range of measures that will be introduced under the BSS to mitigate the risk of pedal application error, which is believed to be rare but can have serious consequences. In addition, TfL has mandated that all new buses must have a camera installed in the drivers' footwell so that footage can be reviewed in incident investigations.

9.7 A higher standard of non-slip flooring will also be introduced as part of the 2019 BSS specification. This will help to reduce the unacceptably high number of slips, trips and falls that occur on board buses.

9.8 Further on in the BSS roadmap, Advanced Emergency Braking (AEB) will be required on all new-build buses from 2024. In advance of this date, we intend to begin a road trial of AEB in 2020, which is expected to run for 2-3 years. The aim of this trial will be to provide confidence to TfL, bus operators and bus manufacturers that the technology performs correctly and is beneficial in terms of reducing road casualties in London.

9.9 It is important that details of all vehicle changes are communicated effectively to drivers. We will work together with the operating companies and the trade unions to ensure that all drivers are engaged and familiarised with the new features and technologies.

9.10 All changes to vehicle design will be robustly monitored and evaluated, a process which will include collecting feedback from drivers and analysing the effectiveness of the changes in terms of casualty reduction.

List of appendices to this report:

Appendix 1 – London Bus Driver Fatigue Research: Final Report

List of Background Papers:

Bus Safety Programme, Safety, Sustainability and Human Resource Panel, 27 September 2018
Bus Safety Programme, Safety, Sustainability and Human Resource Panel, 23 January 2017
Bus Safety Programme, Safety, Accessibility and Sustainability Panel, 30 June 2016
Bus Safety Programme, Safety, Accessibility and Sustainability Panel, 10 March 2016

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Loughborough University

Bus Driver Fatigue

Final Report

Transport Safety Research Group

vti

May 2019

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Glossary of abbreviations

Term	Acronym	Definition
Blood alcohol concentration	BAC	The percentage of alcohol in the blood stream.
Body Mass Index	BMI	The measurement based on height and weight to determine whether or not an individual is overweight
Electrocardiogram	ECG	A physiological measure used to examine heart rate
Electrooculography	EOG	A physiological measure used to examine blink duration
Epworth Sleepiness Scale	ESS	A subjective scale used to determine daytime sleepiness
Fatigue risk management system	FRMS	An evidence based, data-driven process which measures fatigue risks
Heart rate variability	HRV	The variation in the time between heart beats. A faster heartbeat would lead to a lower HRV
Health and Safety Executive Fatigue Risk Index	HSE FRI	A tool used to determine the risk arising from fatigue associated with a particular work schedule or shift
Karolinska Sleep Questionnaire	KSQ	A questionnaire used to measure subjective sleep and sleepiness
Karolinska Sleepiness Scale	KSS	A subjective rating scale of sleepiness ranging from 1 (highly alert) to 9 (having to fight to stay awake)
Obstructive sleep apnoea	OSA	A sleep disorder characterised by interrupted breathing during sleep
Randomised Control Trial	RCT	A method for evaluation an intervention in which people are randomly allocated to a group receiving an intervention, or a group not receiving an intervention
Root mean square of the successive differences	RMSSD	A statistical tool used to assess heart rate variability
Standard deviation	SD	A statistical measure of distribution of scores used to show the range of responses
Sleep efficiency	SE	Total sleep time, expressed as a % of time in bed
Sleep onset latency	SOL	The time between going to bed and falling asleep
Stockholm University Stress Scale	SUS	A subjective rating scale of stress ranging from 1 (highly relaxed) to 9 (very stressed, at the limit of what I can do)
Total sleep time	TST	The total amount of time spent asleep as shown by actigraph data

Executive summary

Bus drivers are exposed to a wide range of occupational factors that potentially increase their vulnerability to fatigue, including prolonged driving conditions, 24-hour operations, variable shift patterns, and urban traffic congestion. The nature of the job also limits the degree of control that drivers have over the timing of breaks, their sleeping patterns, diet and opportunity to exercise, which can further exacerbate the risk of fatigue-related problems. Despite these risk factors there has been a lack of research investigating fatigue in city bus drivers. Across six research tasks the current work demonstrates that fatigue is a problem for London bus drivers. The contributing factors to fatigue are wide and at times complex. There is a lack of current policy and regulation pertaining to fatigue leading to inconsistencies between operators. Across all operators, drivers report feeling unable to discuss fatigue with their employer and employers face difficulties in knowing how best to manage fatigue. A series of potential solutions are proposed across five key areas (education, working conditions, schedules, open culture and health).

Transport for London (TfL) requested independent research services regarding fatigue in London bus drivers. The research reported here was commissioned by TfL to understand the present situation with regard to fatigue and this report provides a roadmap to investigate solutions and to delve deeper into some of the observations made by the authors. This project sought to understand the extent and nature of fatigue, the contributing factors to fatigue, and what solutions could be implemented to address fatigue. The key components of this report are 1) a targeted literature review focusing on sleepiness and fatigue amongst bus drivers, and a broader review of fatigue prevention strategies, 2) a review of internal policy for managing fatigue, 3) focus groups with bus drivers, 4) interviews with managers, 5) a survey of bus drivers, 6) on-road observation study, and, 7) discussion of potential solutions.

Extent and nature of fatigue: Taking into account the findings from each task it can be concluded that fatigue is present. 21% of survey respondents indicated that they have to fight sleepiness at least 2-3 times a week, and 36% of respondents had a ‘close call’ due to fatigue in the past 12 months. Multiple examples of fatigue were discussed during each focus group, with managers also showing an awareness of fatigue during interviews. Despite the small sample it was observed first-hand in the on-road study with drivers obtaining an average of 4 hours and 50 minutes sleep before an early morning drive, with objective measures of sleepiness later being observed during data collection.

Key causes of fatigue: A wide range of factors contribute towards driver fatigue. Not every driver may experience every factor, and the impact of any particular factor varies for any specific driver at different times. Across each of the research tasks several key contributors to fatigue were apparent, these include: shift work and shift irregularity, sleep quality and quantity, overall health of drivers, a disciplinary culture, stress and mental overload whilst driving.

Potential solutions: Potential solutions are proposed across five areas. Several of the solutions and overall themes overlap or complement each other, supporting the notion of a holistic approach, encompassing or addressing aspects of each of the themes, to provide the most benefit in terms of reducing fatigue. It should be noted that none of the proposed solutions have been formally evaluated. Across each of the proposed solutions, there is a need for a shared responsibility. All parties (drivers, managers, operators at all levels, TfL, borough councils, unions, and the Department for Transport [DfT]) have a part to play in implementing any proposed solution. In order for any solution to be successful, parties must not give up too early. There is no quick fix for reducing fatigue and a long-term commitment is needed. With this, it is important to have a step-by-step approach in

which small changes are implemented to start with at a level which will be acceptable to all parties. After this acceptance a more sophisticated solution may be implemented over time. The proposed solutions are broadly split into five categories:

Education: Providing education to drivers on the importance of good quality sleep, sleep management, and the drivers responsibility to manage their sleep. Education should also extend beyond drivers to include managers, shift schedules, and operators as a whole.

Working conditions: Providing and ensuring regular evaluation of suitable facilities for drivers to eat and rest, as well as keeping buses well-maintained to reduce driver stress.

Schedules and rosters: Working to ensure that the design of schedules takes driver fatigue into consideration. This includes changes relating to protecting rest and break times, reducing variability in shift start times, increasing running times, using forward rotations, and avoiding spread-overs.

Open culture: Moving away from a discipline-based culture, to an open culture in which drivers feel comfortable talking about fatigue related issues. This includes improving the relationship between drivers, managers and controllers, increasing the ability to report near misses, and forming a fatigue working group which also includes drivers. A further aspect of an open culture would be an openness to new technology including aspects such as using biomathematical models for fatigue roster modelling.

Health (including sleep health): Creating interventions aimed at improving the overall health of drivers (and subsequently improve their sleep and wellbeing). This could include things such as reducing driver stress, providing health screenings, and providing suitable healthy food options for drivers.

It should be noted that these solutions were informed by the results obtained in the six tasks of this project. Although certain solutions may have been implemented across other occupational settings, the solutions discussed in this report have not yet been evaluated amongst bus drivers. The six tasks are summarised below:

Literature review: The first task was a targeted literature review which found only 26 scientific papers specifically investigating sleepiness and fatigue amongst bus drivers. In contrast, a search for truck driver fatigue using Scopus, returned 384 scientific papers. The small number of available papers demonstrated that this topic is under researched. This is likely due to the risk of fatigue/ sleepiness amongst bus drivers having been underestimated. Nevertheless, a review of previous driving research has shown that the risk of being involved in accident more than doubles when driving fatigued. Some key contributors to fatigue amongst bus drivers were identified in the literature review, these include: shift schedules, driving regulations, tight routes and time pressures, and working conditions. The literature also contained some suggestions for how to counteract sleep and prevent fatigue amongst bus drivers. These included: education, fatigue monitoring/ detection technology, improvements to bus conditions, and schedule changes. However, there is minimal research which has investigated the effectiveness of countermeasures amongst bus drivers.

Policy review: Task 2 was a review of the fatigue management policies from the 10 London bus operators. This review showed that at the time of review none of the 10 operators had a formal or specific fatigue policy, however most operators recognised that fatigue was an issue that needed to be addressed. Although all operators are following legislations relating to driving hours and rest periods, only two operators reported having additional parameters in place to ensure drivers do not become fatigued.

Driver focus groups: For task 3, focus groups were conducted with small groups of 6-8 drivers from each of the 10 operators. Across all of the sessions fatigue was seen to be a problem, with all drivers having experience, or knowing about such an experience in others, of feeling sleepy whilst driving the bus. However, fatigue is not discussed between drivers as a general rule. From these focus groups, several factors were identified as contributors to fatigue, these include: working overtime, staying up too late and therefore having insufficient sleep, spending time with family, other non-work commitments, shift schedules, and work pressure.

Manager interviews: Managers who would respond if a driver reports feeling tired, or if a driver has an incident appearing to be caused by fatigue/sleepiness were nominated by each of the ten London bus operating companies and interviewed. From the interviews it was clear that managers recognise that fatigue is a problem, for example, seeing it as a contributor to serious incidents. As a result, managers wanted to create a more open culture in which drivers feel comfortable talking about fatigue and sleepiness. However, whilst managers would encourage drivers to report fatigue, results from the driver focus groups showed that generally drivers did not feel comfortable reporting instances of fatigue for fear of being disciplined.

Driver survey: For task 5, an online survey was open to all London bus drivers (total = ~25,000), with 1,353 completing the survey. The survey questions specifically looked at drivers' work, sleep, health, and some general background information. The results of the survey showed that fatigue/ sleepiness is a problem for drivers, with 21% reporting that they have to fight sleepiness at least 2-3 times a week whilst driving the bus. A variety of factors in relation to sleep quality and quantity, work, and health emerged as contributors to fatigue amongst bus drivers.

On-road study: The final research task (task 6) was an on-road study focusing on a small group of drivers on a single route through London. This study was the first of its kind to conduct an on-road investigation on a live bus route. Buses and participating drivers were equipped with recording equipment to measure vehicle metrics (such as GPS) and physiological measures (blink duration and heart rate). Drivers took part in the study twice, once during an early morning drive and once during a daytime drive. Prior to these drives, drivers recorded their sleep in a diary and wore a motion watch to obtain objective sleep measures. Although there were no road crashes during the on-road study, the results showed that most drivers did not obtain sufficient sleep prior to early morning drives. It was hypothesised that sleepiness would be most present in the early morning drive, however sleepiness/ fatigue was observed in both drives. This is likely due to two different types of sleepiness/ fatigue being present. In the early morning drive sleepiness is likely a result of working during circadian lows and not obtaining enough sleep, whilst fatigue in the daytime drive is likely a result of completing a highly demanding task.

Future challenges: Although this report demonstrates that fatigue is a problem amongst London bus drivers, there are a few limitations. First, the samples used in each research task may not be fully representative of all London bus drivers. Although steps were taken to ensure that a wide variety of drivers were able to participate in the research, it is not possible to include the views and experiences of all London bus drivers in this project. Furthermore, there is a possibility that the drivers who opted to take part in this research are those who have experienced, or have a particular interest in, fatigue. There were also logistical difficulties inherent in planning and executing the on-road study, which led to cases of missing data. The on-road study was also limited in terms of time and mileage as the research was only conducted on one London bus route. As such, further research across more routes and different shifts would be useful. Another limitation is that the proposed solutions for reducing bus driver fatigue have not yet been subject to randomised control trials.

These limitations show that further research is needed. Further research may focus on expanding the data collected in the on-road investigation, comparing fatigue levels between inner city and suburban bus routes, or comparing fatigue between new and more experienced drivers. Further work is particularly needed to evaluate the effectiveness of the solutions proposed in this report.

Despite the limitations discussed, the current research is extremely important as it greatly increases our knowledge on fatigue/ sleepiness amongst bus drivers, and our awareness of the associated safety issues. Bus drivers are an understudied group within research relating to fatigue. The research presented in this report is the first of its kind to investigate bus driver fatigue so widely, by using a combination of research methods (including the first on-road investigation of its kind), this work has clearly demonstrated that sleepiness/ fatigue needs to be considered in the context of London bus drivers.

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1 Introduction

1.1 Background

Transport for London (TfL) put out a call for tender to investigate the prevalence of fatigue amongst London bus drivers, to which Loughborough University and The Swedish National Road and Transport Institute (VTI) responded. The aim of this work is to understand if fatigue is a problem for London bus drivers, and if so, investigate the nature of this problem and propose solutions. To achieve this, the following research questions were addressed:

1. What is the extent and nature of fatigue in London bus drivers?
2. What are the key causes of fatigue? Are there patterns of working, demographics or any other factors that are correlated with fatigue in London bus drivers?
3. Based on the findings to questions 1 and 2, what solutions should we be implementing or trialling to reduce fatigue and the risk of associated incidents?
4. How effective are these solutions at reducing fatigue and by extension, fatigue related collisions or safety incidents?

A programme of 6 research tasks were undertaken in order to achieve the stipulated project brief. These were followed by a discussion of the potential solutions based on the findings. The 6 research tasks were:

- Task 1: Literature review
- Task 2: Internal policy review
- Task 3: Focus groups with bus drivers
- Task 4: Manager interviews
- Task 5: Driver survey
- Task 6: On-road observation

This document is the final report at the end of the project timeline. This report contains the finalised methodology, findings, and recommendations for potential solutions based on these findings. The report will also discuss some potential avenues for future research.

1.2 Project scope

This project is investigating fatigue/sleepiness amongst London bus drivers. Wherever possible, all 10 bus operating companies (excluding 'Dial a Ride') are included.

Within the project, driver fatigue is considered to be a psychological and/or physical impairment experienced by a driver (either subjectively or objectively) which has the potential to reduce optimal performance. Drivers experiencing fatigue may invoke strategies and resources in attempt to mitigate the effect. Specifically, fatigue will be considered to be multifaceted, encompassing pressures from both endemic sleepiness related to human biology, and task related fatigue. The considered facets are:

- Sleepiness due to insufficient sleep and/or time of day. This includes the circadian[1] and homeostatic[2] pressures all people suffer from and experience, and the added pressures resulting from shift work.

[1] Our circadian rhythms are biological processes displaying a near 24-hour cycle driven by an internal body clock, with peaks and troughs occurring throughout the cycle.
[2] Homeostatic pressure is a process which builds over time telling us that we have been awake for too long and that it is time to sleep.

- Task related fatigue due to the nature of work driving a bus in city environment resulting in an inability to continue, or impairment in performance caused by
    - Time on task due to the same activity going on too long.
    - Overload of cognitive demands during times of exposure to demanding workload. This element this is strongly interrelated with stress.
    - Underload of cognitive demands during times of monotonous activity.
    - Physical muscle fatigue due to physical exertion, for example, steering the bus.

Stress is a multifaceted concept, in this project we look at driver stress both in terms of an adaptive physiological response that mobilises the body's energy reserves to face everyday challenges but also as a subjective feeling of not having enough resources to meet the demands of one's environment. Stress is a continuum; extreme stress has the potential to lead to mental health conditions, however, it should be noted that this was not the direct focus of stress within the context of this report.

In several research tasks, drivers were directly asked about, or referred to, stress. These instances are referred to this as self-reported stress. In some of these cases, drivers used the word stress to refer to other experiences. In these instances, phrases such as mental/ cognitive overload, workload, or pressure are used to indicate the specific experience being described.

1.3 Structure of the report

This report begins by describing the methodology used in each of the research tasks (section 2). The next section (3) discusses the findings from research tasks 1-6, as well as considering some implications from each individual set of findings. Section 4 presents the proposed solutions which were formed based on the results of the previous research tasks. Finally, section 5 discusses some of the limitations to the current research, and presents suggestions for further work.

2 Methodology

The research tasks undertaken in this project received full ethical approval from Loughborough University (HPSC Reference Number: C16-62).

2.1 Task 1: Literature review

Search Approach

A systematic search was conducted, extracting scientific literature relating to bus driver fatigue from published journal and conference articles, government and non-government reports, and other bus driver fatigue-related literature. Throughout the literature and within occupational settings, the terms “fatigue” and “sleepiness” are generally used interchangeably, however, within the scientific literature there is usually a distinction between the two. Whereas “sleepiness” is defined as the physiological urge to fall asleep, usually resulting from sleep loss (Dement & Carskadon, 1982), “fatigue” has been defined as the inability to continue a task or activity because it has been going on for too long (Bartley & Chute, 1947), this includes both overload and underload situations (May & Baldwin, 2009).

Four databases (*SafetyLit*, *Scopus*, *Pubmed,* and *TRID)* and Google Scholar were reviewed. The search for bus driver specific papers was restricted to documents published within the last 12 years, and which included at least an English abstract. The search was conducted using the following terms: “bus driver”, or “coach driver”, and “fatigue”, “sleepiness”, “drowsiness”, and “tiredness”, across different databases to maintain consistency.

In total, only 26 papers were identified that were specific to bus driver fatigue, highlighting that fatigue within this population is currently an under researched area. A summary table of these documents is provided in Appendix A.

Scope

The focus of this literature review is to identify the documents relevant to bus driver fatigue and sleepiness. Due to the limited results specific to bus drivers, research findings relating to fatigue in other professional and non-professional drivers have also been considered. The identified literature was considered from two perspectives: firstly, to understand the context of fatigue (extent, nature, and causes), and secondly, to understand the evidence for solutions to manage bus driver fatigue.

2.2 Task 2: Internal policy review

Two approaches were employed to review fatigue policies within the 10 London bus operators: (1) a questionnaire requesting general details about each operator and (2) a request for details of the operator’s policy for fatigue management. Respondents to the questionnaire were free to complete this without input from the researchers. Operators who do not have a formal fatigue management policy were asked to provide other policy documents which have any content relating to fatigue management, for example, driver handbook, fitness for work rules and so on. This was not a review of the documents which each operator actually had, but rather the documents they believed they had in relation to driver fatigue. The review of each individual operator’s internal fatigue management policy was conducted in order to compare the similarities and differences of approach between the London bus providers. Prior to the completion of the policy review, respondents were sent a list of documents received in this context, and were asked to confirm that these were correct.

2.3 Task 3: Focus groups with bus drivers

Driver discussion groups were held to explore the experiences of fatigue when bus driving. The groups were intended to investigate the issues which bus drivers find significant in relation to fatigue. A focus group discussion guide of questions and prompts was developed to ensure each group followed the same format (see Appendix B). The focus group guide was informed by issues identified during the literature review and the prior knowledge of the researchers, with the aim of answering the following questions:

1. Do bus drivers believe fatigue/sleepiness to be a problem in their industry?
2. How is fatigue/sleepiness managed at work?
3. How do problems like stress and threats/violence contribute to driver fatigue?

2.3.1 Participants/ recruitment

The research study contact person at each operator was contacted by e-mail and asked to assist with the focus groups by identifying a suitable depot or garage and the relevant contact who is based there. A group of 6-8 drivers to include experienced drivers, with a balanced mix of those who have been employed long-term together with those having been driving for a shorter period (but for at least one year) were then invited to attend the discussion. The researchers also requested that a room be made available which was suitable in size and privacy for the discussion.

2.3.2 Procedure

At the beginning of each group, drivers were provided with an information sheet explaining the background to the research and providing contact details of the research team. Participants were then asked to sign an informed consent form which included details about the recording of the discussion. Basic (anonymous) demographic data was also collected from the participants in a very short questionnaire. The participating drivers were encouraged to treat the experience as an informal discussion about their experiences of fatigue and how it is managed at work, and to express their honest opinions. It was stressed that the research (and therefore the discussion) is really important for future fatigue management in the industry. Drivers were urged to talk to each other and to the researchers during the discussion and thereby share experience. It was emphasised to participants that all information they provided would be confidential, with no individuals or operators being identified in any reports.

The data collection took place in October and November 2018 at a London bus depot or garage nominated by the operator. The discussion occurred in a private room where it could not be overheard by anyone outside and no managers were present. Focus groups were facilitated by two researchers, with one consistent individual being present at all of the groups and undertaking the three driver interviews.

2.3.3 Analysis

The discussions were audio recorded, transcribed and analysed using a thematic approach allowing themes to develop both from the research questions and from the narratives of the participants. The themes were discussed and devised by two researchers.

2.4 Task 4: Manager interviews

A total of 11 one to one telephone interviews with a range of managers were conducted. The manager interviews followed on from the bus driver focus groups to determine whether a mismatch exists between how drivers are managing fatigue and how managers believe that fatigue is being managed. The data collection took place in November 2018.

2.4.1 Participants/ recruitment

The research study contact person at each operator was contacted by e-mail and asked to assist with the manager interviews by identifying a suitable manager or supervisor to be interviewed. Participants were defined as 'A person who directly supervises drivers and discusses issues encountered during driving'. The participants were therefore a selection of immediate driver supervisors and higher-level managers within the bus companies.

2.4.2 Procedure

A manager interview question guide was produced in order to ensure each interview followed a similar format (see Appendix C). The guide arose from the findings of the literature review, the bus driver focus groups, and the prior knowledge and experience of the researchers. The manager interview question set was specifically designed to explore managers' views of fatigue, their perception of the causes and consequences, strategies to manage fatigue and their experience of fatigue in driving incidents. The interviews explored the understanding of fatigue and sleepiness in the industry, its effects, and how it is managed.

2.4.3 Analysis

The interviews lasted 30-45 minutes and were audio recorded, transcribed and analysed using a thematic approach allowing themes to develop from the research questions, the results from the focus groups and from the narratives of the participants.

2.5 Task 5: Driver survey

2.5.1 Procedure

All drivers working for the 10 London bus operating companies were eligible to complete the driver survey. The survey was developed to identify the prevalence of fatigue and identify factors which lead to experiencing fatigue. The survey was available to complete online or in paper format. Primarily, the survey was distributed by a link to the online version (through emails, letters, and posters or business cards containing a QR code).

The survey questions covered the following topics:

- How prevalent is driver sleepiness?
- How do background factors such as age, gender, socioeconomic factors, but also type of employment contribute to driver fatigue/sleepiness?
- What working and health conditions are associated with severe driver sleepiness?

The core questions were translated from the Swedish 35 item questionnaire designed and used to measure fatigue in Swedish bus drivers (Anund, Ihlström, Fors, Kecklund & Filtness, 2016). Additional questions were added which arose from the prior knowledge and expertise of the researchers, as well as the responses from the focus groups. The survey was split into five sections: (1) questions about your work as a bus driver, (2) questions about your sleep, (3) questions about your health, (4) questions relating to yourself as a bus driver, (5) background questions. The full list of survey questions can be found in Appendix D.

2.5.2 Analysis

The survey was open to respondents for three months. Two types of analysis were conducted: (1) general descriptive statistics to explore the extent and nature of bus driver fatigue, and (2) logistic regressions to determine which factors significantly predicted fatigue.

Within the regression analyses relating to sleep, there are 5 sleep indexes which have been entered as predictor variables. As part of the survey, drivers were presented with 20 statements related to sleep and were asked to "indicate the degree to which the following have happened to you during the last 3 months". Drivers responded to each statement with one of six options ranging from "never" to "always (5 or more times a week)". All indices (apart from the fatigue index) were part of the Karolinska Sleep Questionnaire (KSQ) as used by Anund et al. (2016). Based on these responses a numerical average was calculated for several statements to form each of the 5 sleep indexes, as follows:

- **Sleep quality index**: difficulty falling sleep, repeated waking, waking up too early, disturbed or worried sleep
- **Sleepiness index**: feeling sleepy at work, feeling sleepy during leisure time, fighting to stay awake throughout the day, involuntary falling asleep at work, involuntary falling asleep during leisure time
- **Fatigue index**: physical fatigue, mental fatigue
- **Impaired waking index**: difficulty in waking up, not feeling alert on waking up
- **Suspected sleep apnoea index**: snoring, difficulty catching your breath whilst sleeping, interrupted breathing during sleep

2.6 Task 6: On-road observation

The on-road observation used an explorative design to understand fatigue during normal bus driving. Tasks 1-5 were designed to collect a wide range of information across all operators; in contrast Task 6 was designed to obtain detailed information from a small group of drivers employed by one operator.

All operators were eligible to volunteer to participate in the on-road observation. A document explaining the intended study design was circulated, and three operators expressed interest. Individual discussions were held with each operator detailing the requirements and logistical limitations for both the research design and business operations. Following these discussions one operator was selected to participate in this task.

The on-road study was designed to examine fatigue in normal driving operations using physiological and vehicle recording metrics. It was important that the design allowed the investigation of specific research questions but did not compromise the delivery of service for the operator. The design features were informed by the literature review, focus groups, preliminary survey findings, and the prior expertise of the research team.

2.6.1 Participants/recruitment

A total of 16 drivers were included in the study (mean age 46 years, range 35 to 57 years). Volunteers were recruited among drivers scheduled to work the selected bus route during the study period.

The inclusion criteria were:

- Working as a bus driver on a regular basis
- Working as a bus driver for at least 2 years
- Not being on sick leave for more than 3 days in the last 2 months
- Agreeing to wear electrodes and to be recorded
- Agreeing to use an actigraph and complete sleep diaries in the days before the study

2.6.2 Procedure

Bus drivers working on a Central London bus route were observed whilst driving on the same route twice, once in an expected alert condition and once in an expected fatigued condition. The bus was in service for both of the conditions. The selection of alert and fatigue conditions were based on the survey and focus groups results from other data collections within the project, where it was found that drivers perceived the morning shift to be more fatiguing than the daytime shift. Daytime driving (start after 9am) was therefore used as the alert condition, whereas morning driving (start before 7am) was used as the fatigue condition. Before the on-road data collection started, the drivers were invited to a preparation meeting at the bus depot. They were informed about the study and were familiarised with the equipment used for physiological monitoring and the subjective scales of sleepiness and stress. After giving their informed consent to participate, the drivers received sleep monitors (actigraphs), a sleep and wake diary, and a background questionnaire. Four days before each drive, the participants wore actigraphs and filled in the sleep and wake diary to keep track of their sleep/wake history.

On the day of the data collection the test leader met the bus driver at the depot and followed them to the bus. The test leader briefed the bus driver about what was going to happen during the drive and when everything was clarified the driver was asked to sign an informed consent form.

Thereafter, the bus driver was equipped with the physiological measurement equipment. This was completed either at the depot or in the bus depending on if it was a morning or day shift.

The test leader rode the bus during the drive and data collection was started when the bus reached one of the end stations of the selected bus route. Data collection continued until the driver reached the other end of the route.

The drivers were instructed to drive as they normally would and not change anything about their normal driving. Every five minutes during the drive, the drivers verbally reported their level of sleepiness and stress (see section 2.6.3.3).

After the drive, the electrodes were removed, and the participants answered questions about their experiences during the drive.

2.6.3 Self-reported data

2.6.3.1 Background questionnaire

All participants completed the background questionnaire which was a slightly modified and shortened version of the survey (see section 2.5 and Appendix E). It comprised questions about demographics, sleep, working conditions, health and bus driving. The questionnaire also included the Karolinska Sleep Questionnaire [KSQ] (Nordin, Åkerstedt & Nordin, 2013) to assess sleep quality. Subjective sleep quality was assessed on five indices (see section 2.5.2).

2.6.3.2 Sleep and wake diary

Four days before both the 1st and 2nd experimental day, the participants started to fill in sleep and wake diaries. The diaries included questions about night sleep (sleep quantity, sleep quality and sleeping problems), to be answered upon waking, and questions about fatigue and experiences during the day, to be answered at bedtime.

2.6.3.3 Sleepiness and stress ratings

The level of subjective sleepiness during each drive was assessed by using the Karolinska Sleepiness Scale [KSS] (Åkerstedt & Gillberg, 1990). Individuals were required to indicate on a nine-point scale

how sleepy they had felt (1 = extremely alert to 9 = very sleepy, great effort to keep awake, fighting sleep) on average during the previous 5 minutes.

Subjective stress level was assessed using the Stockholm University Stress Scale [SUS] (Dahlgren, Kecklund & Åkerstedt, 2005), which is a nine-point scale ranging from 1= Very low stress (I feel very relaxed and very calm) to 9= Very high stress (I feel very tense and pressed – at the limit of what I can stand). This was also reported as an average for the previous 5 minutes.

Every five minutes during the drive, the participants were prompted with a beeping sound to report sleepiness and stress into the microphone. They were instructed at the start of each drive to first give the rating for sleepiness and thereafter the rating for stress level. These verbal ratings were audio recorded.

This method has been used in previous on-road investigations (Anund, Fors, Ihlström & Kecklund, 2018) and did not have a negative impact on driver safety. Drivers were also informed that if for any reason they were unable to report their sleepiness or stress (such interacting with passengers or traffic controllers) then they should skip this reporting and continue after the next beep. All testing protocols were subject to Loughborough University ethical procedures which includes a risk assessment.

2.6.3.4 After driving questionnaire

The bus drivers' experiences from the drive were captured with help of questionnaires after the experiment. The questionnaire consisted of 10 questions and encompassed topics of sleepiness, stress, worry, if control was lost during the drive and if any countermeasure were used to stay awake. The questions were both of scale type as well as free text answers. The ratings were given on a scale from 1 to 7 or 1 to 5 where 1 was lowest and 7 or 5 the highest problems, see Appendix F.

2.6.4 Actigraphy

Four days before both the 1st and 2nd experimental day, the participants started to wear the actigraph (MotionWatch, CamNTech Ltd, Cambridge, UK). The actigraph was worn around the non-dominant wrist like a watch and recorded movement (see Figure 2.1). The face of the "watch" was blank, it did not provide any information or distraction to the driver during participation. Participants were instructed to wear the actigraph day and night, except when bathing or showering.

The participants were instructed to press an event marker button on the actigraph every time they went to bed ('Lights Out') and woke up ('Got Up'). This was done for night sleep and for daytime naps. 'Lights Out' and 'Got Up' times were manually checked and compared against the sleep diaries. Sleep analysis was done using MotionWare software. For each sleep period, the following measures were analysed:

- Total sleep time (TST); the total time spent in sleep according to the sleep analysis.
- Sleep efficiency (SE); the total sleep time expressed as a percentage of time in bed (the total elapsed time between the 'Lights Out' and 'Got Up' times).
- Sleep onset latency (SOL); the time between 'Lights Out' and the time point of falling asleep as identified by the sleep algorithm.

Statistical analyses were performed on sleep measures from the night before each drive as well as on mean TST, SE and SOL of the four days before each drive. Naps were included in the calculation of four-day averages.

Figure 2.1: Actiwatch

2.6.5 Physiological measurements

Heart rate and eye blinks were collected using a Vitaport 3 system. Electrodes were placed mainly on the right side of the face, which was facing away from the passengers, and on the body (see Figure 2.2). For the purposes of statistical analyses, heart rate variability (HRV) will be reported. The main idea is that increased heart rate and reduced heart rate variability is an indication of increased stress, whereas reduced heart rate and increased heart rate variability is an indication of sleepiness/fatigue. A more detailed description of the physiological measurements can be found in Appendix G.

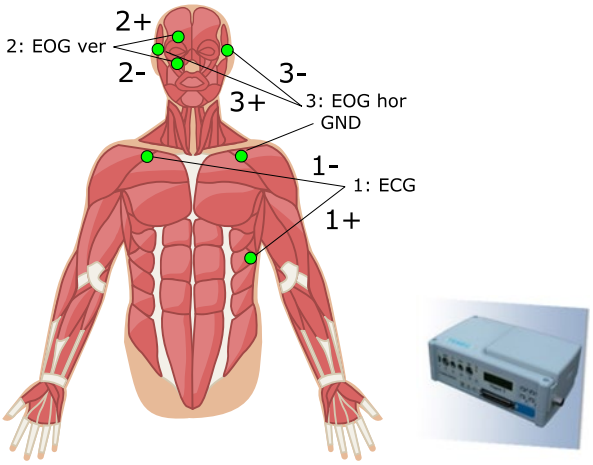


Figure 2.2 Electrode placement and the Vitaport

2.6.6 Driving data

The buses were equipped with a Vbox (Racelogic Ltd, Buckingham, UK), cameras, GPS and a microphone for measurements of driving related data and drivers self-reported sleepiness and stress levels. Two cameras were installed, one facing forward and one facing the driver (see Figure 2.3).

Speed, acceleration, and deceleration data were averaged in five-minute intervals for each drive (described in the unit m/s^2). Geographical position was used to code each five-minute interval into one of five pre-defined zones along the bus route. The two systems were synchronised with a time stamp.

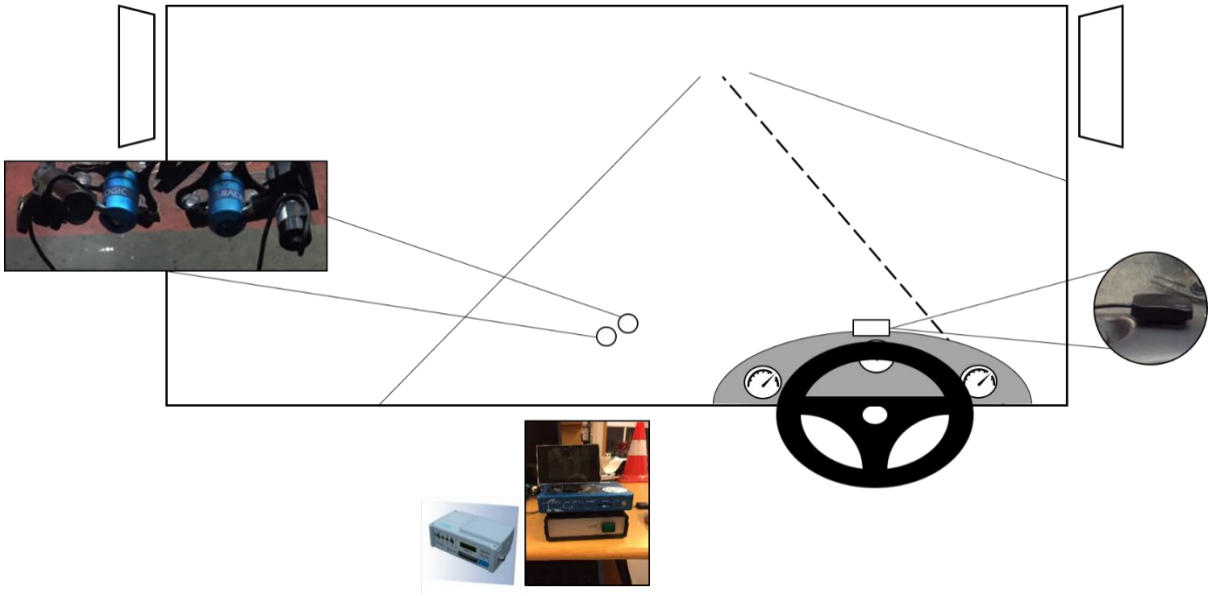


Figure 2.3 The bus set up for the on-road study. Two cameras were attached to the windscreen (one facing the driver and one facing the road) in a location which would not obstruct the drivers view. The GPS antenna was attached to the top of the instrument cluster. The vbox, vitaport and beeper phone were placed out of view of the driver in a small storage compartment to the lower left of the steering wheel.

2.6.7 Statistical analysis

Statistical comparisons were made between the results from the sleep and wake diaries and the actiwatches for rest days, morning shifts and daytime shifts. Statistical comparisons were also made between several physiological and behavioral variables from the early morning and daytime drives. Further details of these statistical analyses can be found in Appendix G.

3 Key findings

3.1 Task 1: Literature review

3.1.1 Key findings

3.1.1.1 Overview of Fatigue - the Extent and Nature of Driver Sleepiness

Driver fatigue is a globally known causation factor contributing to road traffic accidents, injuries, and deaths in various transportation operations (Williamson et al., 2011; Bioulac et al., 2017; Zhang, Yan, Wu, & Qiu, 2014). Although there are various definitions of fatigue, certain features such as subjective sleepiness, changes in psychological state, decrements in performance, reduced alertness, and difficulties with sustained attention, can be used to characterise fatigue (Williamson, 2007). For the purpose of this review, driver fatigue is considered to be "*a psychological and /or physical impairment which has the potential to reduce optimal performance. Fatigue is considered to be multifaceted, encompassing pressures from both endemic sleepiness relating to the body's homeostatic and circadian pressures, and task related fatigue".* Regardless of specific vehicle types, research has shown that 27% of drivers have experienced difficulty keeping their eyes open while driving within the past month, and 41% of drivers admitted to falling asleep behind the wheel at least once in their lifetime (Tefft, 2010). In relation to professional drivers, these figures are increased, as 38% of drivers have experienced fatigue at least once per week, and 45% of drivers reported nodding off whilst driving in past 12 months (Friswell & Williamson, 2008). Furthermore, in a study on Swedish city bus drivers, more than 40% reported fighting to stay awake while driving at least 2-4 times a month, and 19% had to fight to stay awake at least 2-3 times a week (Anund et al., 2016) (the results of this study are discussed further in relation to the driver survey in section 3.5)

Fatigue is thought to be a contributing factor to approximately 15% to 30% of road traffic crashes globally (Connor et al., 2002; Horne & Reyner, 1995; Phillip et al., 2014). However, there are difficulties associated with measuring fatigue after a crash takes place. Where specific effort is put in to train police officers to identify fatigue, estimates are higher than when relying on standard police recording (Horne & Reyner, 1995).

Research has shown that one of the main causes of fatigue related transport incidents are attentional lapses due to insufficient sleep (Philip & Åkerstedt, 2006; Philip et al., 2005; Schwarz et al., 2016). Several other factors can also result in fatigue, including insufficient or lack of sleep, extended or prolonged wakefulness, disruptions to circadian rhythms, and sleep disorders (Zhang et al., 2014). External influences such as time spent on task can also impact fatigue (Williamson, 2007).

Fatigue risk management has become an important component of health and safety within occupational settings, however the varying definitions of fatigue (Phillips, 2015) (as previously mentioned) can result in varying interpretations. For instance, fatigue could occur from engaging in both simple tasks for long durations, such as monotonous long-distance driving, as well as highly complex short duration tasks, such as difficult city driving due to cognitive overload (May and Baldwin, 2009). Another factor to consider is the state of the driver at the start of their driving duty, as this will likely impact fatigue and sleepiness. For example, a bus driver who suffers from a sleep disorder or poor or disturbed sleep may begin their duty with a high level of sleepiness, even if the duty begins soon after waking or during times of peak alertness, and an individual who has an additional job may experience cumulative fatigue from previous activities. Fatigue and sleepiness are important factors related to safety, and both should be considered in terms of fatigue risk management.

Driver sleepiness research is an important and current topic. For example, in 2015 in the U.S, a panel of sleep science experts, traffic safety, legislators, vehicle manufacturers, federal representatives, insurance groups, advocacy groups, and public and work safety groups convened to build consensus on research, programme, and policy objectives to address risks, consequences and countermeasures related to drowsy driving (Higgins et al., 2017). The panel highlighted issues with the extent of fatigue as a problem in driving and in crash investigating and reporting. It is difficult to accurately assess the impact of fatigue-related issues solely through the crash data. This is due to the fact that crash data only highlights those who have experienced or reported an accident or incident in which fatigue was a contributory factor, whereas many people suffering from the effects of fatigue possibly are not involved in crashes or incidents. The panel stressed the need for ongoing research to understand people's knowledge, attitudes, and behaviours in relation to driver sleepiness. There have been recent attempts to work on this, for example research in Sweden led to the refinement of crash checklists for police officers to complete upon arriving at road accidents. Results highlighted the issue of sleepiness in relation to driving and road accidents, the need for routines and tools to identify driver sleepiness, and for officers to be adequately trained in such techniques and ensure the time to complete any sleepiness checklists (Anund, 2008; Gertler, Popkin, Nelson, O'Neil, 2002).

Previous research has shown that driving while fatigued results in decrements in performance for both simple and complex tasks, impaired attention, slowed reaction times, and loss of conscious awareness while behind the wheel (see Williamson et al., 2011 for review). The implications of this have been demonstrated in both studies on real roads (using naturalistic and experimental approaches) and simulator studies. A recent analysis of research relating to sleepiness and motor vehicle accidents, including 17 papers with over 70,000 participants, found that the risk of motor vehicle accidents more than doubled due to sleepiness at the wheel (Bioulac et al., 2017). Fatigue also results in a higher rate of lane crossings (Filtness, Reyner, & Horne, 2012; Hallvig et al., 2014), reductions in hazard perception (Smith, Horswill, Chambers & Wetton, 2009), and an increased tendency to become distracted (Anderson & Horne, 2013). It has also been found that extended wakefulness results in neurobehavioral impairments similar to those found following alcohol consumption (Watling, Armstrong & Smith, 2013), with research indicating that driving performance after 17 hours of wakefulness (Dawson & Reid, 1997), or after nocturnal driving of two hours (Verster, Taillard, Sagaspe, Olivier & Phillip, 2011), is equivalent to a blood alcohol concentration (BAC) of 0.05%. In the U.K., the legal driving limit for BAC is 0.08%, in Scotland and most EU countries, the legal limit is a BAC of 0.05%.

There are links between time of day and driving incidents, with the highest number of crashes or incidents occurring during times when alertness would be at its lowest due to our circadian rhythms (Åkerstedt, Connor, Gray & Kecklund, 2008; Connor et al., 2002; Garbarino, Lino, Beelke, Carli, & Ferrillo, 2001; Horne & Reyner, 1995; Milter et al., 1988). Our circadian rhythms are biological processes displaying a near 24-hour cycle driven by an internal clock, with peaks and troughs occurring throughout the cycle. These rhythms influence several behavioural, physiological and metabolic functions, including body temperature, and alertness. The lowest points of the circadian rhythm produce the strongest drive to sleep, with alertness beginning to decrease in the late evening, and reaching its lowest point between 02:00 and 04:00. An additional, smaller dip in alertness is also experienced in the early afternoon between 13:00 and 15:00.

Sleepiness risk in relation to driving is often underestimated, and certain occupations have been found to have an increased risk of crashes or near misses from sleep loss, including shift workers, (Colquhoun, 1976; Di Milia et al., 2011; Folkard & Monk, 1979; Gold et al., 1992; Richardson, Miner & Czeisler, 1990; Stutts, Wilkins, Osberg & Vaughn, 2003) truck drivers (Lyznicki, Doege, Davis &

Williams, 1998; McCartt, Rohrbaugh, Hammer & Fuller, 2000; Stoohs, Guilleminault, Itoi & Dement, 1994), and professional drivers (Bunn, Slavova, Struttmann & Browning, 2005). Compared to non-professional driving, certain aspects of professional driving are risk factors for fatigue including a sedentary and restricted posture, long hours of driving, irregular shift patterns, and a unique work environment (Bunn et al., 2005; Chaiard, Deeluea, Suksatit & Songkham, 2019; Öz, Özkan & Lajunen, 2010). Typically, irregular working hours (Wilson, Chattington & Marple-Horvat, 2008), night shifts (Barth & Franke, 2009; Bella & Calvi, 2013; Chaiard et al., 2019; Stanton & Young, 1998; Wilson et al., 2008), extended shift duration (Barth & Franke, 2009; Bella & Calvi, 2013; Stanton & Young, 1998), reduced sleep (Stanton & Young, 1998), high work load (Stanton & Young, 1998), early morning shifts (especially in combination with monotonous driving) (Barth et al., 2009; Bella & Calvi, 2013; Thiffault & Bergeron, 2003ab), and low task demand (Dunn & Williamson, 2012), are contributing factors to fatigue, many of which are regularly experienced by drivers. It might be thought that professional drivers are more capable of staying alert compared to non-professional drivers, however this is not the case (Anund, Ahlström, Fors & Åkerstedt, 2018). Professional drivers self-reported being more alert, but more objective measures show greater sleepiness and more involuntary lane crossings compared to non-professional drivers.

3.1.1.2 The Key Causes of Driver Fatigue Relevant to Bus Drivers

Bus driver fatigue has typically received less attention (Tse, Flin & Mearns, 2006), as the majority of sleepiness research has previously been conducted with non-professional drivers (Åkerstedt et al., 2013; Hallvig et al., 2013; Sagaspe et al., 2008), or truck drivers (Hanowski, Wierwille, & Dingus, 2003; Kecklund & Åkerstedt, 1993; Mitler, Miller, Lipsitz, Walsh, & Wylie, 1997). Fatigue in relation to bus drivers has sometimes been considered under the category of heavy goods vehicles (HGVs) (Biggs, Dingsdag & Stenson, 2009), however, the driving styles and environments of drivers of HGVs and buses are significantly different.

The limited available research has indicated that sleep loss is a major issue for city bus drivers, with approximately 45% of Swedish bus drivers having to fight against sleepiness at least 2-4 times each month whilst driving the bus, and 19% of drivers fighting to stay awake at least 2-3 times per week (Anund et al., 2016). A previous study conducted in Edinburgh found that 20% of bus drivers reported excessive daytime sleepiness, reporting scores of more than 10 on the Epworth Sleepiness Scale (ESS), a subjective scale designed to assess trait daytime sleepiness. Respondents are asked where they rate on a 4-point scale (0-3) their usual chances of falling asleep or dozing off during eight different activities. The ESS score can range from 0-24, with scores of 10 or more being associated with excessive daytime sleepiness. 12% of drivers were also found to have fallen asleep at the wheel at least once per month, 7% had had been involved in an accident and 8% of drivers had experienced a near miss due to sleepiness while driving (Vennelle, Engleman, & Douglas, 2010).

Bus driver fatigue is not solely a European issue, with reports of fatigue and sleepiness levels, accidents and near misses, occurring frequently in Peruvian bus drivers (Deza-Becerra et al., 2017; Liendo, Castro & de Castro Rey, 2010). Questionnaire data has shown that 74% of bus drivers experienced fatigue, 25% of drivers experienced sleepiness, and 35% of drivers reported ‘nodding’ while driving (Deza-Becerra et al., 2017). The studies also highlighted the reduced sleep obtained by bus drivers, with 9% of drivers sleeping less than six hours per day (Deza-Becerra et al., 2017), and approximately half (43% of informal drivers and 48% of formal drivers) of drivers reporting sleep of less than seven hours a day (Liendo et al., 2010). Under sleeping is also prevalent amongst bus drivers working early morning shifts as actigraph data shows that they do not go to bed early enough to get sufficient sleep before the next days early morning shift (Diez et al., 2011). As sleep loss and being awake for too long are contributing causes of driver fatigue (Åkerstedt, Connor, Gray &

Kecklund, 2008), reduced sleep and inadequate rest are important issues to consider. Self-report data has also shown instances of poor sleep quality, insomnia, and increased risk of obstructive sleep apnoea (OSA), as risk factors associated with excessive daytime sleepiness in Korean bus drivers (Kim et al., 2017), with 13.2% of questionnaire respondents reporting ESS scores of more than 10, 68.4% of drivers experiencing poor sleep quality, and 10.2% of drivers reporting moderate to severe insomnia.

3.1.1.2.1 Shift Schedules and Irregularity

Long working hours have been shown to contribute to increased sleepiness and increased crash risk (Robb, Sultana, Ameratunga, & Jackson, 2008), particularly when combined with sleep loss, lack of breaks, and difficult working conditions (Pylkkönen et al., 2015), all of which bus drivers are likely to experience. Scheduling affects drivers directly, impacting their sleep opportunities, rest breaks, and length of working. The added passenger and traffic elements can potentially result in reduced breaks and extensions of driving time, both of which are factors related to fatigue. The literature search identified 10 studies which directly considered shift work pattern and bus driver fatigue.

Bus driver shift pattern scheduling has also been shown to impact crash risk (Wang & Wu, 2019), with research conducted in Malaysia reporting that bus accidents were significantly related to work schedule (Abdullah & Von, 2011). Research exploring fatigue variables reported that one of the main contributing factors of driver fatigue was unrealistic scheduling (Biggs, Dingsdag & Stenson, 2006), which was supported by further research identifying nine causation factors of fatigue, several of which were related to work schedule: tight route schedules, turn-around and shift irregularity, and extended shift cycles (Biggs et al., 2009).

Split shift working (or spreadovers), involves dividing the work duty into two parts, with a long break (> 2 hours) in between often to meet the needs of commuters. Long working hours and insufficient sleep have been found to be associated with split shifts (Anund et al., 2016; Sando, Mtoi, & Moses, 2010), with objective evidence of increased sleepiness during the afternoon in those drivers who had previously worked a morning shift, compared to those who had been off duty (Anund et al., 2018). However, subjective data has shown that in general, split shift working is not associated with detrimental health and psychosocial issues, and that only the drivers who stated problems with split shift working reported poorer health, increased stress, interference with social life, reduced sleep quality, fatigue, and lower work satisfaction (Ihlström, Kecklund, & Anund, 2017). The added issue with split shift working is what drivers decide to do or can do on their break, determined by break length, commute times, and available facilities. A study found that a small number of bus drivers relaxed or napped either at work or at home during their rest break. However, a larger number of drivers engaged in various activities during their break, including non-driving duties, eating, shopping, attending appointments, and reading (Sando et al., 2010). Differences in self-reported sleepiness levels for bus drivers on differing schedules have also been shown (Lee, Kim, Byun, & Jang, 2017). Alternating day shift workers, who displayed characteristics of irregular shift patterns and extended working, suffered from increased sleepiness compared to daily split shift bus drivers.

3.1.1.2.2 Regulation, Tight Route, and Night Schedules

Regulations can be put in place to specify a required maximum shift and minimum break duration; Table 3.1 shows the driving hours and regulations, as specified by the Vehicle Operator Services Agency [V.O.S.A] (2015), for both Great Britain and the European Union.

Table 3.1: Drivers' hours and regulations

	GB Domestic	EU rules
Daily driving limit	10 hours	9 hours (this can be increased to 10 hours twice a week)
Maximum continuous driving	5½ hours, then 30-minute break	4½ hours, then 45-minute break
Maximum spreadover	16 hours	13 hours (or 15 hours up to 3 times a week)
Minimum daily rest	10 hours (can be reduced to 8½ hours up to 3 times per week)	11 hours (can be reduced to 9 hours up to 3 times a week)
Weekly limits		56 hours maximum driving
Fortnightly limits	Must include 1 rest day	90 hours maximum driving

Driving hour regulations are complicated by overlapping jurisdictions. For example, drivers of passenger vehicles in the UK should follow the EU regulations outlined in Table 3.1. However, London bus drivers (along with most urban bus drivers) fall into an exemption category within the EU rules as buses do not travel routes longer than 50km. Therefore, the GB domestic rules apply.

There is also no central regulation or requirements on fatigue risk management. Each independent operator may develop and follow their own procedures for fatigue management including fatigue related accident and incident reporting and shift pattern design. From the literature search, seven studies were found that related to regulations, schedules and bus driver fatigue.

Bus drivers can face challenging tight route schedules, especially in the city centre during peak hours, which has been reported as a contributing factor to fatigue. Although schedules are designed to work the majority of the time, factors such as traffic, passengers, and headway can impact route timings. Since the delay margin for buses is small, time pressure is likely to be generated and accumulated, restricting turnaround times and breaks, and hence increase their overall stress level (Biggs et al., 2009). Another fatigue consideration is the complexity of the route. Although drivers' fatigue levels have been shown not to be affected by route type, a study found that certain fatigue symptoms (including yawning, wanting to lie down, and eye strain) were significantly higher following a complex city centre route (Makowiec-Dabrowska et al., 2015), compared to the 'easier' route outside the city centre. This coincides with the differences in task related fatigue discussed earlier, and work underload and overload.

Driving during the circadian low, for example night or early morning driving, is known to contribute to driver fatigue (Åkerstedt et al., 2008; Chaiard et al., 2019; Diez et al., 2011). There are reports of high incidences of night time sleepiness and daytime sleep disruptions in night shift bus drivers (Krishnaswamy, Chhabria, & Rao, 2016), with the most commonly reported time of day for being involved in, or almost having, an accident occurring between 01:00-04:00 (Liendo et al., 2010). In response to a number of bus crashes that occurred during the early morning in Malaysia, a proposal was put forward to stop the operation of buses during the early morning (00:00-06:00). However, unless other aspects of fatigue management were also addressed, such as poorly managed shift schedules and compliance with driving and working hours, it was concluded the full potential benefits would not be realised (Mohamed et al., 2012). Other instances of poorly managed schedules have been reported, with an increase in frequency of night driving (Liendo et al., 2010). For example, in Peru, 44% of formal bus drivers and 54% of informal bus drivers experienced five or more night shifts per week (Liendo et al., 2010), and 41% of the bus drivers drove seven nights per week, with 21% of drivers reporting they drove for more than five hours without a break (Deza-

Becerra et al., 2017). Research has also shown that drivers starting early morning shifts or finishing night shifts have an increased risk driving to or from home (Åkerstedt et al., 2008).

3.1.1.2.3 Working Conditions

Besides schedule design, the working conditions of bus drivers is also an important issue to consider in relation to fatigue. Five papers were found that addressed bus driver working conditions.

Both physical and psychosocial factors are known to contribute to the health and well-being of bus drivers, with some of these stressors including poor in-vehicle ergonomics, shift work, lone working, and risks of violence and intimidation, (Tse et al., 2006). Research has found that the condition of the bus is important, with indications that cabin ergonomics contribute to fatigue (Biggs et al., 2009), and that an improvement in overall bus condition would reduce accident rate (Abdullah & Von, 2011). In general, bus drivers may be exposed to heat, vibration, and noise due to bus design and road infrastructure, therefore leading to increased stress levels (Abdullah & Von, 2011; Biggs et al., 2009). City bus drivers potentially spend a large proportion of driving time sitting in congested traffic, facing time pressures, which could contribute to psychological stress, as well as stress related to the physical aspects of manoeuvring the bus (Ahlström, Gink Lövgren, Nilsson, Dukic Willstrand & Anund, 2018). Access to adequate driver facilities is also an important aspect, with reports of drivers sleeping in inappropriate places between shifts, detrimentally impacting sleep quality (Deza-Becerra et al., 2017). Stress is one of the strongest predictors of fatigue for city bus drivers, as are threats of violence and a lack of rest facilities (Anund et al., 2016).

3.1.1.3 Fatigue Countermeasures and Prevention Strategies for Bus Drivers

Countermeasures and prevention strategies for sleepiness in general, as well as in relation to driving, have received considerable attention over the past two decades. However, frequently used or popular countermeasures to sleepiness are not always available for bus drivers, who face a more restrictive working environment. Non-professional drivers, or long-haul truck drivers, can stop the vehicle and take a break if needed, possibly even nap, whereas bus drivers have strict time schedules to follow and are unable to take a break from driving whenever they would like. Even measures such as opening a window, or listening to the radio, which are frequently adopted by non-professional drivers (Gershon, Shinar, Oron-Gilad, Parmet, & Ronen, 2011), despite their ineffectiveness (Schwarz et al., 2012), are not availible to bus drivers. There are also limitations in terms of eating and drinking whilst driving, as well as the possibility that drivers face restricted access to facilities, potentially influencing their food and drink chioces. Additionally, in order to find effective countermeasures there is a need to understand the cause of fatigue (May & Baldwin, 2009). A bus driver that suffers from sleepiness can be helped by sleep and caffeine intake with some limitatons, on the other hand a bus driver suffering from fatigue due to overload may benefit from a change in activity or a short break.

Fatigue research and the evaluation of countermeasures has mainly been concerned with long haul, non-city driving, and is especially limited in relation to bus drivers. Fourteen papers were found that considered fatigue countermeasures and solutions for bus driver fatigue.

3.1.1.3.1 Education

Educating bus drivers on aspects of shift work, sleep, and effective countermeasures to sleepiness is an important prevention strategy, with research highlighting the need for educational interventions (Deza-Becerra et al., 2017), encouraging good sleep hygiene (Diez et al., 2011). Research conducted with night bus drivers in India focused on self-report coping practices and post shift sleep hygiene (Krishnaswamy et al., 2016), and showed that a range of strategies were employed by drivers to cope with nocturnal sleepiness, including consuming coffee or tea (16.7%), chewing tobacco (12.8%),

smoking (6.1%), and walking (3.9%). The paper concluded by highlighting the need for education relating to shift work, sleep hygiene and napping, as well as the controlled use of caffeine to promote wakefulness. Education surrounding the use of countermeasures was also recommended in terms of split shift working (Anund et al., 2018). A previous study concluded that attention needed to be focused on the occupational sleep hygiene of bus drivers, as well as emphasising the importance of sleep in relation to driving, and the treatment of sleep disorders within the bus driver community (Razmpa, Niat & Saedi 2011). Good sleep hygiene practices and overall health and well-being are important elements of shift work, with sleepiness a common risk factor for professional drivers. Studies have shown that body mass index (BMI) was correlated with sleepiness (Santos, Bittencourt, de Assis Viegas & Gaio, 2013), and that poor sleep quality, insomnia, and high risk of OSA, are three factors associated with excessive daytime sleepiness amongst bus drivers (Kim et al., 2017).

3.1.1.3.2 Scheduling

Several papers referred to the association between work schedules and bus driver fatigue, with suggestions of improved schedules possibly resulting in reduced accident rates (Abdullah & Von, 2011). It is important that a well-organised management system is developed, that allows enough recovery period for bus drivers (Machin & Hoare, 2008). Length of duty and work hours should also be considered, after it was found that reaction time in bus drivers decreased sharply after four hours of duty (Sang & Li, 2012), and that minimum rest periods may result inadequate time for rest and sleep (Sando et al., 2010). There have also been reports of cumulative fatigue increasing with the number of days and hours worked (Sando et al., 2010), and multi-day driving patterns are associated with higher crash risk (Wang & Wu, 2019). Schedule analysis can be aided by the use of biomathematical models. By rescheduling using an optimization model, research found that crash incidence could be reduced by approximately 30% (Wang & Wu, 2019), however the model used is theoretical in nature and dependent on probabilities, rather than a validated biomathematical model, therefore this figure should be interpreted with caution.

Consideration of working patterns is important, with reports of fatigue issues relating to split shift working (Anund et al., 2018; Sando et al., 2010). However, a previous study found that subjectively, split shift working only showed fatigue and psychosocial issues in those workers who reported problems working split shifts (Ihlström et al., 2017), possibly suggesting a more individual approach to shift patterns. However, individual preferences for roster schedules could also create additional issues relating to how individuals manage themselves, their rest, and their work pattern, and what their main motivation is for requesting a certain pattern. Restricting or stopping driving during times of the circadian low, for example during the night or early hours of the morning when alertness is at its lowest, could also impact fatigue related incidents, however this is possibly unrealistic in terms of 24-hour operations. This was suggested, as previously mentioned, in Malaysia to try and address the issue of increased crashes during these times (Mohamed et al., 2011), however it was concluded that a more holistic approach was needed, considering all aspects of road safety risk.

3.1.1.3.3 Fatigue-detection Technology

Advancements in technology have led to the development of certain fatigue-detection systems, aimed at helping drivers and operators detect and monitor fatigue states. The systems mainly function by collecting and measuring physiological outputs using a variety of measures, to produce information relating to driver fatigue. A vision-based fatigue detection system was proposed for use in bus driving, incorporating exisiting cabin cameras to measure a range of variables including face detection, eye detection, eye openess estimation, and percentage of eyelid closure, in order to predict the drivers fatigue state (Mandal, Li, Wang & Lin, 2017). Experimentally, despite the low

resolution images and the viewing angle, the system was able to distinguish between sleepy and drowsy states, and the normal driving state. Research has also suggested the use of EEG recordings to monitor the fatigue state of bus drivers (Wang & Wang, 2013). However, certain measurements, especially physiological measurements, may be considered to be intrusive, or even distracting. Systems also need to be monitored and interpreted, resulting in the need for additional time and possibily training and expertise. Devices have also been recommended to be installed into buses to detect fatigue-related decrements in driver performance (Sando et al., 2010). Although not suggested as a countermeasure to fatigue, research measuring fatigue in bus drivers utilised a range of performance tests including reaction time, speed perception, and attention (Sang & Li, 2012), which possibly could be incorporated into fitness for duty tests or an evaluation of driver state before, during, or after their duty period.

3.1.1.3.4 Bus Condition and Design

As it has been suggested within the limited literature that bus cabin ergonomics contribute to fatigue (Abdullah & Von, 2011; Biggs et al., 2009), an improvement of the overall road conditions and bus cabin ergonomics could be viewed as a relevant countermeasure, such as improvements to drivers' seats (Sang & Li, 2012). In terms of physical fatigue and driving, a study focusing on steering systems showed that additional features such as dynamic steering assisted with the physical manoeuvring of the bus, reducing required muscle activity and stress on the body, which in turn should aid neck and shoulder issues and provide a more relaxing work environment overall (Ahlström et al., 2018). Considering ways to reduce mental and cognitive overload for drivers may also be beneficial in terms of counteracting fatigue (Sang & Li, 2012). Design should also be considered in relation to the need for drivers to interact with passengers, and the potential risk and stress due to threats and violence.

3.1.1.4 Fatigue Countermeasures and Prevention Strategies Not Specific to Bus Drivers

3.1.1.4.1 Road Safety Campaigns

Road safety public awareness campaigns have typically been relied upon to prevent fatigue amongst the general public. A comprehensive meta-analysis indicated an accident reduction of 9% in response to these campaigns (Phillips, Ulleberg & Vaa, 2011). Research found that following a national campaign that reached 13% of its audience, professional and non-professional drivers adopted certain fatigue prevention strategies, such as stopping and resting for 15 minutes (Adamos, Nathanail, & Kapetanopoulou, 2013). However, this is a complex issue and transport operations possibly require an approach that incorporates a variety of information such as training and education, organisational strategies, scheduling practices, vehicle and environmental solutions, and research and evaluation (Hart, 2013). There is also the issue of responsibility for fatigue management, as non-professional drivers carry individual responsibility. However, for professional drivers, not only do they carry the individual responsibility, but also responsibility to their industry or company, and the regulatory body that they belong to (Gander et al., 2011). This can be quite confusing, especially if there is a chain of responsibility involved.

3.1.1.4.2 Education and Training Approaches

Educating drivers about the causes and consequences of fatigue in relation to their work, is often advocated as a countermeasure to reduce fatigue. Generally, drivers are educated on various aspects, such as the physiology of fatigue, fatigue management strategies, the safety implications, and any company policies involving fatigue. For example, education to raise awareness of fatigue in heavy vehicle drivers has been adopted in New Zealand (Firestone & Gander, 2010), and in the rail industry in the UK and United States (Office of Rail Regulation, 2012; U.S. Department of Transport, 2012). In some instances, traffic offender programmes involve aspects on fatigue, however these

broad programmes focus more on other issues such as drug and alcohol impaired driving, and are not designed to address fatigue (Faulks, 2012). Despite interest in driver sleepiness increasing over the past two decades, few regulators consider fatigue management a compulsory or mandatory component of becoming a professional driver.

This approach can be useful in terms of educating drivers who are not aware of the risks of fatigue. A study showed that immediate knowledge gained at the time of fatigue management training was largely retained, and many heavy vehicle drivers implemented fatigue strategies both at home and at work (Gander, Marshall, Bolger & Girling, 2005). However, for individuals who drive while fatigued due to other factors, the benefits of educational approaches may be unlikely to make an impact. Research has shown that for non-professional drivers, the main reason for driving sleepy is due to the desire to reach their destination, or because of time constraints (Armstrong, Obst, Banks & Smith, 2010; McCartt et al., 2000; Nordbakke & Sagberg, 2007). Professional drivers have the added pressures of financial and business demands (Firestone & Gander, 2010), highlighting the need to ensure that fatigue countermeasure strategies go further than solely driver education (Jackson et al., 2011). A recent study with long-haul truck drivers investigating the effects of alertness management training on sleepiness found the training had no impact on driver alertness (Pylkkönen et al., 2018) proposing that driver education as a sole measure is not sufficient to alleviate driver sleepiness. However, driver education is an important approach, as research has shown that drivers regularly use countermeasures which have been shown to be ineffective at counteracting sleepiness (such as stopping to take a walk, opening a window, or turning on the radio) (Anund, Kecklund, Vadeby, Hjälmdahl & Åkerstedt, 2008; Schwarz et al., 2012). Driver education would also tackle the issue of the perception of driving whilst sleepy. Typically, in terms of crash risk factors, drivers list sleepy driving after risky behaviours such as speeding, drink driving, and driver distraction (Pennay, 2008; Vanlaar, Simpson, Mayhew & Robertson, 2008), suggesting driving while sleepy is not perceived to be a risky behaviour.

It is important to understand that the purpose of education and training is most often to change an individual's behaviour, which takes time. Therefore, a one-off, training session is unlikely to impact driver behaviour and reduce fatigue and sleepiness. It may be that an approach including a series of sessions, would elicit behaviour change. This could potentially be conducted using an e-learning platform rather than face-to-face. However, again, it would require participant engagement and motivation to change.

3.1.1.4.3 Fatigue Risk Management

Traditionally, transport operator fatigue has been managed by rules and regulations stating upper limits of time spent at work, however criticism has argued that these rules have failed to consider important causes of operator fatigue (Fourie, Holmes, Bourgeois-Bougrine, Hilditch & Jackson, 2010; van Dongen & Mollicone, 2014). Recently, transport companies have been encouraged to implement evidence-based safety management systems with risk assessments and mitigation strategies tailored to company policies, roles, and documents, which should be supported by management commitment to safety, data-driven continuous learning, and a positive safety culture (Lerman et al., 2012). Fatigue risk management systems can vary, ranging from simple or informal approaches, to complex, formal approaches, however the main consideration is the assessment and mitigation of fatigue risks. A recent review focusing on fatigue-related risk, exposure factors and control measures for land and sea transport, identified 13 measures to monitor or control fatigue risks, including: optimal staffing and schedule design, optimisation of breaks and naps, monitoring of actual hours worked, health screening and treatment, monitoring of fatigue symptoms while operating, control of fatigue while operating, and performance monitoring and assistance (Phillips, Kecklund, Anund &

Sallinen, 2017). The review also highlighted the importance of incorporating measures to support any implementation of measures to monitor and control fatigue and associated risk factors, such as organisational learning, training and education, management commitment, recruitment and selection and safety climate and culture.

3.1.1.4.4 Policies Regarding Rest Periods and Hours of Work Restrictions

In an attempt to prevent drivers operating when fatigued, restrictions to work schedules are often utilised by organisations and regulatory bodies, which may include limits to work hours. This approach was established in the 1930s to balance working conditions and pay, limiting commercial drivers to set driving, work, and rest periods (Gander et al., 2011). Restricting hours of work remains a popular mitigation to fatigue risk within transport operations. Non-professional drivers are encouraged to stop and take a break from driving if they begin to feel sleepy or notice symptoms of sleepiness or fatigue, however this may not be as easy or realistic for professional drivers who have schedules to keep. There are certain legal requirements regarding driving hours and rest breaks for long distance truck drivers as well as coach and bus drivers, specifying maximum driving times without breaks, as well as minimum rest requirements between duty periods. Although the impact of work and rest polices on driver fatigue and driver safety has had limited evaluation, research has shown support for the regulation of work hours. It was found that participating in safety behaviours such as driving within statutory hours and observing rest breaks, was negatively correlated with exhaustion, job tension, and fatigue (Boada-Grau, Sánchez-García, Prizmic-Kuzmica, & Vigil-Colet, 2012), and compared to drivers who did not have a rest break, taking breaks during an 11 hour shift reduced the odds of a crash by 68% for one break, 83% for two breaks and by 85% for three rest breaks (Chen & Xie, 2014). However, specific durations of rest breaks and the time the break was taken within the 11-hour drive were not taken into consideration in this study. In comparison, evidence has shown the detrimental effects of working 12 hours or more in one shift. Research involving a large sample of more than 10,000 US workers in various occupations found that working 12 or more hours in a shift was associated with a 37% increased hazard rate (Dembe, Erickson, Delbos, & Banks, 2005). Another important consideration is the ability to cope during extended shifts, and with sleep loss and night work, which has been found to deteriorate with each additional long or overnight shift (Anderson et al., 2012). This research shows that human performance can be negatively impacted by fatigue, and that by setting a limit for hours of work, fatigue related injuries and incidents could be reduced, especially in industries that involve repeated exposure to long, extended shifts (Anderson, Grunstein, & Rajaratnam, 2013).

However, attempting to tackle fatigue solely by introducing specified hours of work and rest can be associated with several issues. Unfortunately, compliance may be a problem, with no guarantee that workers will follow the suggested hours (Balkin, Horrey, Graeber, Czeisler & Dinges, 2011), especially if the recommendations lack additional sanctions. Fatigue detrimentally impacts individuals at different rates, which is not taken into consideration by implementing general driving restrictions and informing drivers to stop after a certain period of time (Williamson, Friswell, Grzebieta & Oliver, 2013). Fatigue can also be due to a number of reasons, both sleep related (including sleep loss, sleep debt and extended wakefulness), or task related (including task duration, and mental under or over load). Therefore, restricting work hours does not account for the cause of fatigue, which may require different and distinct approaches in terms of countermeasures (May & Baldwin, 2009). Fatigue is an important and dangerous issue, and one that needs to be addressed. Encouraging drivers to be aware and notice signs and symptoms of fatigue to enable them to act before safety related incidents occur, may be a more practical fatigue risk management strategy, rather than a standalone overarching approach (Williamson et al., 2013).

3.1.1.4.5 Policies Regarding Other Industry Approaches to Managing Fatigue

In general, there are other management-level guidelines and approaches regarding fatigue, apart from training and rostering polices, that are advocated by workplace health and safety and transport authorities. However, the majority of guidelines can be vague, and it is not always clear how or to what extent they apply in practice. For example, The Health and Safety at Work Act 1974 states that employers have a duty of care for on-the-road work activities and work-related driving activities, and the Management of Health and Safety at Work Regulations 1999 requires health and safety to be managed effectively.

Within the rail industry in the UK, regulation 25 of the Railways and Other Guided Transport Systems (Safety) Regulations [ROGS] (2006) cover fatigue management practices, alongside other guidance. These regulations, as well as the Office of the Rail Regulator who has a Good Practice Guide for management, have resulted in the development of Fatigue Risk Management Systems (FRMS) by London Underground and TfL Rail, comprising of three training courses for frontline staff, managers, and work schedule compliers. However, as the requirements of ROG25 apply to public transport under the sphere of ROG, they do not apply to all forms of road transport which includes buses. The Rail Safety and Standards Board [RSSB] have also developed several fatigue management guides (RSSB, 2012) and good practice guides for managing occupational road risk associated with driver fatigue. The UK aviation industry requires airlines to provide initial and recurrent fatigue management training to crew members, personnel responsible for the preparation and maintenance of crew rosters, and management of said personnel. However, the training programme can be established by the individual airlines rather than an overarching, standardised fatigue management programme, although a training syllabus is suggested within the European Aviation Safety Agency (EASA) Flight Time Limitation (FTL) regulations, including causes and effects of fatigue, and fatigue countermeasures (Civil Aviation Authority [CAA], 2017).

There are different approaches to fatigue management within industries, however it is clear that both individual employees and employers or operators all contribute to the management of fatigue.

3.1.1.4.6 Other Available In-vehicle Technologies

There are limitations associated with organisational and regulatory approaches to driver fatigue (Balkin et al., 2011), as well as the notion that drivers often downplay the consequences of fatigue, ignoring the early warning signs (Fletcher, McCulloch, Baulk, & Dawson, 2005), or failing to take appropriate action prior to a collision (Alioua, Amine, & Rziza, 2014). Due to this, in-vehicle technologies have emerged as a solution to mitigate the effects of fatigue. It has been proposed that the ideal fatigue monitoring system should firstly ‘predict’ fatigue before safety and productivity is impacted, secondly, ‘measure and monitor’ the effects of fatigue, and lastly, provide an appropriate ‘intervention’ when any deficits are detected or anticpated. Current technological designs to counter fatigue involve driver monitoring technologies, fitness-for-duty technologies, and performance-based monitoring (Balkin et al., 2011).

To detect changes in both driver state and driving performance, a variety of invasive and non-invasive technologies have been proposed (Merat, Jamson, Lai & Carsten, 2012). Current commercially available in-built countermeasure systems are designed to provide feedback via messages and alerts, an example is the ‘coffee cup’ symbol which appears on the instrument panel, usually accompanied by an auditory alert. Other systems provide binary alerts (such as warning/no warning), or continuous feedback in the form of an ‘attentiveness scale’. Vibration feedback has also been developed, delivering alerts via the seat or steering wheel, for example haptic guidance steering systems (Wang, Zhang, Wang, Schnelle & Wang, 2017), usually accompanied by an icon warning. In the majority of cases, these messages must be acknowledged by the driver to clear

them. However, there is limited evidence into the effectiveness of these feedback countermeasures for drowsy driving. Research has shown that simple auditory and visual warnings resulted in improved lane keeping (Berka et al., 2005; Fairclough & van Winsum, 2000), and combined auditory and visual warnings were found to improve driving performance and reduce subjective drowsiness over 4-hour drives (Grace & Steward, 2001). However, these simple in-vehicle countermeasures can reduce the frequency of drowsy lane departures in relatively short drives (Gaspar et al., 2017). Objective physiological and physical measures include electroencephalography (EEG) which measure brain wave activity, eye tracking devices that can detect a range of blink or eye gaze patterns, head pose estimations for head nodding, measures to track heart rate and heart rate variability, actigraphy technology which measures gross movement, and devices to detect yawning (Alioua et al., 2014; Balkin et al., 2011).

Fitness-for-duty approaches often involve vigilance or alertness testing, for example using the psychomotor vigilance test (Baulk, Biggs, Reid, van de Heuvel & Dawson, 2008), performed before a work duty, to assess the drivers' alertness and ability to safely commence a driving shift (Balkin et al., 2011; Ji, Lan & Looney, 2006), or eyelid-based measures (Ahlström et al., 2013). However, results have not been shown to reliably equate to poor driving performance (Dawson, Searle & Paterson, 2014), and approaches such as these can be sensitive to countermeasures such as caffeine or pharmaceuticals, possibly exaggerating alertness and capacity to drive at that time (Balkin et al., 2011). They are also considered impractical for commercial driving (Dawson et al., 2014), and therefore not sufficient as a stand-alone method for predicting a driver's ability to remain alert and safe for the duration of their duty period (Balkin et al., 2011).

Several fatigue monitoring technologies for use in the transport industry are commercially available in the US, UK, and Europe (Dong, Hu, Uchimura & Murayama, 2011). Although not exclusively for fatigue mitigation, camera based Lane Departure Warning Systems (LDWS), which employ various algorithms to estimate the state of the vehicle (speed) and road positioning or alignment (lane width), have been designed to prevent 'run-off-the-road' crashes (Houser, Murray, Shackelford, Kreeb, & Dunn, 2009), and have been distributed within the US trucking industry. Other on-board safety systems have been considered for use within various transport operations, including military vehicle and truck drivers (Dinges, Maislin, Brewster, Krueger, & Carroll, 2005), with the aim of reducing fatigued driving (Dinges et al., 2005; Houser et al., 2009; Kerick, Metcalfe, Feng, Ries, & McDowell, 2013). A review of other avaialble technologies was conducted by Kerick et al., (2013). These technologies include vehichle enviroment monitors (e.g. SafeTrak) which alerts drivers to erratic driving and lane departures, senor-based monitors (e.g. Advisory System for Tired Drivers, ASTiD) which can track steering behaviour, and smartphone apps which can record and evalute sleep history (e.g. Fatigue Calculator). Driver performance feedback technologies could be effective in terms of self-enforcement, by delivering feedback to both the driver and their employer. This approach has been developed and used with the aim of tackling risky driving in young, novice drivers, installing monitoring devices to deliver feedback to drivers and parents (Guttman & Gesser-Edelsburg, 2011).

3.1.1.4.7 Self-administered Countermeasures

Sleepiness countermeasures can be utilised to reduce the likelihood of having a sleep-related crash (Cummings, Koepsell, Moffat & Rivara, 2001), however, there are a range of measures used by drivers, with varying degrees of effectiveness. 'Strategic' measures include not driving during the night and ensuring that adequate sleep has been obtained before driving, however this can be unrealistic in terms of professional driving. Popular measures such as opening the window, turning on the radio, and taking a break, have been shown to be ineffective at improving alertness for

extended periods of time (Horne & Reyner, 1996; Reyner & Horne, 1998; Schwarz et al., 2012), despite these two in-vehicle countermeasures (opening the window/turning on the air conditioner, and listening to music) being utilised more so than effective roadside countermeasures (Anund et al., 2008; Armstrong et al., 2010; Nordbakke & Sagberg, 2007). This therefore highlights the importance of education surrounding the use of effective and ineffective countermeasures to sleepiness.

One of the most effective ways to counteract sleepiness is by taking a 15-20 minute nap, which leads to reductions in physiological and subjective sleepiness, and improves driving performance (Horne & Reyner, 1996, Leger, Philip, Jarriault, Metlaine & Choudat, 2009; Watling, Smith & Horswill, 2014). However, again, for professional drivers this may not be possible due to time constraints and inadequate facilities. An important sleepiness countermeasure is caffeine. Caffeine is found in a variety of products, such as coffee, tea, chewing gum, and energy drinks, and is widely used in Western society to increase alertness (James, 1997). Consuming caffeine has been seen to effectively increase alertness and improve driving performance after 20 minutes (De Valck & Cluydts, 2001; Horne & Reyner, 1996; Reyner & Horne, 2002), with a caffeinated nap (consuming a caffeine drink followed by a short nap), significantly reducing driver impairments, subjective sleepiness, and EEG signs of sleepiness (Horne & Reyner, 1996). The beneficial effects of this countermeasure have also been shown in laboratory studies with other performance measures (Tietzel & Lack, 2002; Wesensten, Killgore & Balkin, 2005), however few countermeasures have been evaluated on real roads.

3.1.1.4.8 Environmental Strategies and Infrastructure

Another common approach to managing fatigue, is the use of environmental or road-based strategies. These include “rumble strips” or audible edge lining, which alerts the driver when they depart the road or highway (Noyce & Elango, 2004), and rest areas that allow drivers to be able to take adequate breaks during shifts (Baulk & Fletcher, 2012). Rumble strips on the centre line have been associated with a 15% accident reduction (Mahoney, Porter & Donnell, 2003; Persaud, Retting & Lyon, 2003), with a 20% reduction in the number of fatalities and seriously injured parties in all crash types, and a 27% reduction in single vehicle crashes (Vadeby & Anund, 2017). A 40-50% reduction for rumble strips on the shoulder (Gårder & Davies, 2006) has also been found, as well the implementation of rumble strips being useful for distracted drivers. However, in terms of sleepiness, the alerting effect of hitting the rumble strip is often short lived, with signs of sleepiness returning after approximately five minutes (Anund et al., 2008).

Crash reduction has been shown in those individuals who utilise rest stops or service stations (Cummings et al., 2001). A later study showed limited effects of motorway service areas, or signs encouraging drivers to take a break prior to service areas for general crashes, however crashes related to sleep did show a reduction (Reyner, Flatley & Brown, 2006; Reyner, Horne & Flatley, 2010). Research has also shown that drowsiness during driving may be prevented to some extent by cognitive alertness maintaining tasks (except sleep deprivation induced sleepiness) (Gershon, Ronen, Oron-Gilad & Shinar, 2009; Oron-Gilad, Ronen & Shinar, 2008; Song et al., 2017).

In terms of road construction and design, laboratory studies have shown that sleepiness increases faster during monotonous driving (Richter, Marsalek, Glatz & Gundel, 2005). However, the majority of driver sleepiness studies are conducted in either driving simulators or in laboratories with monotonous driving conditions. A study investigating indicators of sleepy driving in more challenging conditions found differences in indicators following sleep loss depending on whether the driving was moderately or very challenging, highlighting the importance of the driving situation (Anund, Kecklund, Kircher, Tapani & Åkerstedt, 2009).

3.1.1.5 Gaps and Future Challenges

The review has identified several gaps and future challenges relating to the literature and current approaches to managing driver fatigue.

To summarise, these include:

- There are varying definitions of fatigue, with terms such as “fatigue” and “sleepiness” being used interchangeably both within the literature and within occupational settings;
- In general, the exact number of incidences of fatigued driving is not known due to reporting issues and the fact that the majority of the time, only those involved in crashes are recorded;
- The range of existing countermeasures to fatigue with limited information and evaluation relating to their effectiveness;
- The inconsistencies within different industries at which fatigue management is enforced and training is delivered.

More specific to bus drivers:

- Overall there is a dearth of bus driver focused research in relation to fatigue and fatigue management;
- There is a lack of subjective research exploring bus driver opinion relating to their role as a bus driver, their background and health, their sleep patterns, and also specifically in relation to how fatigue influences or is influenced by bus driving, and how this is managed;
- Objectively measured research is also limited, aimed at investigating bus driver fatigue in real-life, on-road settings.

3.1.2 Summary

Overall, the review has highlighted that:

- Fatigue is considered to be a generic term including both sleepiness due to the circadian low or lack of sleep, and task related fatigue due to both work underload and overload.
- Fatigue in bus drivers is an under-researched area, with only 26 papers in total being identified within the past 12 years. Sleepiness risk in relation to driving is often underestimated.
- Driver sleepiness is an important topic and has been shown to be an issue in other driving groups, and within other industries, contributing to approximately 15%-30% of road traffic crashes. The risk of being involved in a road traffic accident more than double when driving whilst sleepy, and driving performance following 17 hours of wakefulness is the equivalent of a BAC of 0.05.
- Aspects of professional driving are risk factors for fatigue, such as sedentary/restricted posture, long driving hours, irregular shift patterns, extended shift duration, reduced sleep, early morning shifts, night shifts, low task demand.
- Fatigue is a problem globally for bus drivers, resulting from a combination of factors such as scheduling, shift patterns and irregularity, time of day of operating, and working conditions, with many of these directly effecting sleep quality and quantity.
- Many effective countermeasures such as napping, caffeine, and reduced night time driving may not be practical or suitable for bus drivers. Many countermeasures also rely on driver motivation and engagement.

- There is minimal research relating to the evaluation of reported countermeasures in relation to reducing driver fatigue. Therefore, it is difficult to draw conclusions on the effectiveness of certain mitigation strategies.
- Implementing countermeasures to address single aspects may be limited in their potential to reduce driver fatigue compared to a more inclusive, holistic approach.

3.2 Task 2: Internal policy review

3.2.1 Key findings

The two approaches employed to review fatigue policies within the 10 London bus operators were a questionnaire providing general details about each operator and a request for details of the operator's policy on fatigue management with examples of the relevant documents. For the first element, central managers (one from each operator with names being provided by TfL) completed a questionnaire about issues related to fatigue management and to provide some context for their organisation's operations. A variety of personnel responded, for example, Head of Operations, Driving Standards Manager and Transport Safety Manager. This questionnaire can be found in Appendix H. Each operator completed the questionnaire independently, consequently the level detail provided to open ended questions varied.

The questionnaire showed that the number of London bus drivers employed by each operator ranged from 15 to 6,232. The average length of time for which bus drivers have been employed at the operators ranged from 2 years to 10-15 years. The proportion of female drivers ranged from 2% to 15%, with the majority being around 10%. The number of buses in operators' fleets ranged from five to 2500 (with half having more than 1000) and the make/models were numerous; the number of garages in London ranged between one and 17. In eight of the responding operators drivers have a fixed base depot; in the other two, workers operate out of two garages.

With regard to fatigue management policies, no operator provided an existing fatigue management policy, although two operators noted that they were about to address the issue in a more targeted way. In lieu of a formal fatigue management policy, operators were asked to provide any existing documents which contain information which may be relevant to fatigue management e.g. driver hand book, training manuals etc. Nine of the 10 London bus operating companies sent whole relevant documents with a further one answering specific questions and/or sending pages or sections as appropriate. The exact documents provided varied between operators.

Table 3.2 lists the types of policy documents provided. It should be noted that any documents discussed here are those which operators elected to send and which they therefore considered to be pertinent to policy surrounding fatigue/tiredness. As a result, it is possible that operators hold additional policy documents which, for various reasons, they did not share with the researchers. Consequently, the Table shows only where a document was provided; blank cells do not necessarily denote that an operator does not have such a policy document, simply that they did not share it. The range of documents and lack of clarity surrounding the policies provided by the operators both demonstrate the differing stages of comprehension and consideration of fatigue currently being experienced in the bus driving industry in London. Within the policy documents provided there was a range of information which related to fatigue management. The key features of which are noted in Table 3.3.

Table 3.2: List of policy documents provided

Type of policy document	Operator no.									
	1	2	3	4	5	6	7	8	9	10
Documentation detailing fitness to work confirmation procedures	✓									
Driver work hours rules	✓			✓	✓	✓		✓	✓	
Driver handbook	✓			✓	✓				✓	✓
Medical assessment procedures/questionnaires	✓				✓				✓	
Accident procedures and processing included in incident reporting	✓								✓	
Driver training/coaching materials	✓		✓	✓		✓			✓	
Disciplinary and Performance Improvement Policy and Procedure		✓							✓	

Table key: ✓= document provided by operator

Table 3.3: Fatigue management relevant content of policy documents

Fatigue management relevant content in policy documents	Operator no.									
	1	2	3	4	5	6	7	8	9	10
HSE Fatigue and Risk Index Calculator output considered	✓						✓			
Fatigue management content in Driver training			✓	✓					✓	
Fatigue management content in Driver handbook									✓	✓
Regular communications are sent to drivers related to health and wellbeing (leaflets, posters, noticeboards and information screens – may not be fatigue specific)	✓				✓			✓	✓	
Additional parameters applied beyond mandated hours of driving regulations aiming to ensure drivers do not become fatigued	✓								✓	
Medical examinations document mentions fatigue	✓								✓	
Medical self-certification Health Assessment questionnaire – asks about sleeping disorders and medical condition affecting sleep	✓								✓	
Explicit mention of provision of rest rooms at depots and bus stations	✓								✓	
Disciplinary and Performance Improvement Policy and Procedure explicitly mentions fatigue		✓							✓	
Risk assessments and medicals performed regularly on drivers who have medical issues					✓					
Mentor's Guide mentions fatigue as an indication of emotional difficulties						✓				

Table key: ✓= feature mentioned in at least one document provided by operator

It is noteworthy that the policy documents which were provided did not always correspond with the responses to the questionnaires. In particular, all 10 questionnaire respondents noted their legal obligations in relation to driving time limits and communicated this to their drivers either in the driver's handbook, at induction, or in a rule book (sometimes in multiple ways). Only six sent relevant documents, although several stated this to be important in their fatigue management, and some had introduced additional parameters to the regulations to avoid fatigue in their drivers.

Four operators who provided driver training or handbook documents included a specific mention of fatigue (operators 3, 4, 9 and 10). Additional operators provided similar documents but fatigue was not mentioned, specifically two operators provided documents which did not include a consideration of fatigue for each of: driver training materials (operators 1 and 9); new driver induction (operators 1 and 6); driver handbook (operators 1, 4 and 5) and directions to drivers on how to report accidents/incidents and near misses (operators 1 and 9).

Seven operators indicated that drivers were required to confirm their fitness to drive. This was noted either according to the questionnaire responses, where three operators stated drivers confirm their fitness to drive by signing in, and a further two reported having an automated sign-in system making this explicit. Two additional respondents explicitly stated that drivers are responsible for ensuring they are fit for work (rather than stating that they are required to sign in to confirm this). One respondent noted drivers are obliged to tell the employer if they think they are unfit to drive, and another noted their attendance policy states drivers should not work if unfit to do so. In the final operator who provided documents, duty managers make visual checks at sign on when they interact with drivers.

Seven operators noted that procedure on feeling unwell while driving the bus is part of their attendance policy and drivers should stop the bus in a safe place and radio through that they are unwell. Medical assistance may be called, and if it is a case of the driver needing to go home they will be picked up. This issue is generally communicated to drivers at induction or during the training process. Two operators stated that all policies concerning health and feeling unwell are covered in their handbook, whilst another reported no formal policy.

All 10 respondents include a consideration of driver fatigue in their crash/incident investigation system; this takes a variety of forms. For example, via a reporting system capturing various forms of data following an incident (when a driver last worked, how much rest they have had the previous night, how many days since their last full rest day, which shift it occurred on, if the work was overtime or normal work), through the use of a post-accident interview, and by reviewing camera footage where available.

With regard to pre-employment medical fitness tests, seven of the responding operators noted adhering to the DVLA legal requirements according to age. In addition, one operator noted that any of their drivers working night shifts complete a medical questionnaire every two years, with any concerns resulting in a visit to the occupational health doctor. A second operator noted additionally that health checks are introduced if a driver is involved in multiple incidents and another has an occupational health doctor for drivers who have been on long-term sick leave. Only one operator stated that their drivers are not subject to medical fitness tests.

In six operators, drivers are paid by the hour on a weekly basis. Four operators have a weekly wage; in two of these drivers are paid on a salaried basis. One operator has six 'casual' drivers who must work at least one shift every 12 weeks, whilst another has 22 part-time workers who work 2, 3 or 4 days per week. All of the eight respondents running night buses offer financial incentives to work nights, including an enhanced rate of pay, unsocial hours payments and night bonuses.

Most of the operators run a mixture of shifts, including: mixed rota of rolling 'earlies', 'middles' and 'lates' and fixed either early or late shifts. This may include 'family friendly' work, for example 'earlies' may be requested to allow those with young children to be available to collect them from school. Night bus drivers generally work only fixed night-time rotas. All of the operators allow drivers to swap shifts, usually this is achieved by mutual consent between individuals. Requests generally must be made in writing and it is the responsibility of drivers to check adherence to the drivers' hours and regulations when swapping shifts.

Five of the respondents operate 24 hours per day, seven days per week. Of the remainder, one noted that most routes are 20-24 hours, a second stated that it is 24 hours where night services operate. A further respondent noted that some routes are 18 hours, and some are 24 hours, one runs 22 hours per day (04:00-02:00) and the remaining participant has a TfL contract running 04:30-21:00 hours.

Night shifts were defined in a variety of ways:

- Signing on between 19:00 and 02:00, and signing off after 03:00
- Starting anywhere between approximately 20:30 and 01:00
- Duties that start and finish between 18:30 and 10:00, although the majority are between 19:00 and 07:30
- Working between 02:00 & 03:00
- Approximately 23:00 to 06:00
- 22:00 – 04:00 generally
- Not defined but generally finishing after 03:00
- Any duty that works the full hour between 02:00 and 03:00

For five respondents, schedules are planned via their Schedules Department, with two specifying this being done in accordance with the service specification for any given route as set out by TfL and within company agreements. A further respondent mentioned schedules being planned by computer followed by a manual check and update.

At the time of writing there are no imposed TfL requirements or policies on fatigue management for buses, and it is left to the operators to follow legal and union requirements. However, fatigue does feature in the Safety Assurance Process, an ongoing assessment process which has recently replaced annual audits. The assurance score is generated during regular safety conversations with the operators, where TfL Safety Managers talk to staff at all levels, including drivers.

The fatigue questions included in the Safety Assurance Process are as follows:

- Are there fatigue prevention measures included within risk controls in risk assessments?
- Are drivers educated on fitness to drive standards? That is, is there an education programme that informs drivers of the minimum standards that apply in this regard?
- Is driver fitness to drive considered post incident?
- Do drivers know how to declare themselves unfit to drive?
- Is fatigue management considered to be a key risk control?

A relevant public transport comparison is the fatigue management policy related to rail (over ground, tube and tram). In the case of London Underground (operated in-house) and TfL rail (which is contracted to MTR Corporation), regulation 25 of the Railways and Other Guided Transport Systems (Safety) Regulations 2006 (ROGS) and other guidance together cover fatigue management practices are applicable. These Regulations apply to the mainline railway, metros (including London Underground), tramways, light rail and heritage railways. Furthermore, the Office of the Rail

Regulator has a Good Practice Guide for fatigue management from which further Fatigue Risk Management Systems (FRMS) were developed. Since this is driven by ROG regulator, the same policy applies to both tube and overground rail. The FRMS is integrated into TfL's safety management system. Within the FRMS there are requirements for managing the risk of fatigue and also three training courses: one for frontline staff (manage your own fatigue roles and responsibility), one for managers (policy requirements) and one for work schedule compilers (roster design). It is provided to the tram companies, although in contrast to underground drivers, tram drivers are not employed by TfL. Tram fleet and infrastructure maintenance staff all work for TfL, so are subject to the FRMS.

The requirements of ROG25 only apply to public transport domains which come under the ROG remit and therefore are not applied to road transport including buses. Consequently, formal fatigue management is in place to cover drivers of rail related public transport in London. TfL has identified that it does not have a standardised approach across all transport public modes; this has led to a maturity review which has concluded that there is a need to place fatigue management requirements onto TfL suppliers, including buses.

3.2.2 Summary

Within London bus driving, no operator has an explicit policy for fatigue management. This might be expected as TfL does not mandate fatigue management policy. This is in contrast to rail public transport which is subject to dedicated fatigue management requirements imposed by ROG 25. From the policy documentation provided by the operators for review there are indications that:

- None of the ten operators has a formal or specific policy on fatigue.
- Eight of the ten operators stated a recognition of fatigue as an issue to be addressed, with two of these noting they were about to address the issue in a more targeted way.
- Only two operators provided information about using the Health and Safety Executive (HSE) Fatigue and Risk Index, a freely available tool to help prevent driver fatigue.
- All ten operators are aware of the Drivers' Hours and Regulations which mandate maximum working hours.
- Two of the operators indicated that they have put in place additional parameters to these Regulations to help ensure drivers do not become fatigued.
- Most London night bus drivers only work on night-time shifts, although the definition of a night-time rota differs across the operators.
- Most of the operators run a mixture of shifts (earlies, middles, lates), with only two not running at night.
- Drivers can apply for a certain shift at some operators; this includes 'family friendly' work, particularly 'earlies'.
- Shifts are allocated according to route knowledge and experience.

3.3 Task 3: Focus groups with bus drivers

All ten of the London bus operating companies participated in bus driver discussions in some way. That is, eight focus groups with 6-8 participants were held whereas at one operator, two groups of four were organised due to the lack of availability of drivers. The last operator was also unable to provide 6-8 drivers at one time and so arranged three interviews with single drivers.

At the beginning of each focus group, participants were asked to complete a short questionnaire relating to demographic information. The total number of participants in the bus driver focus groups was 65 (including the three interviewees) and 80% were male, with 20% being female. As shown in Figure 3.1 (below) the majority of participants were aged 45-54 years (35.4%), with 26.2% being in

the age range 54-65 years, 21.5% in the age range 35-44 years and the remainder 25-34 years (16.9%).

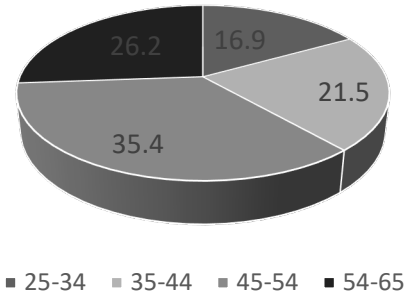


Figure 3.1: Age of focus group participants (%)

The participating bus drivers had been working on average 13 years and 6 months as a bus driver and 8 years 1 month on average as a driver for their current employer. Thirteen participants (21% of those responding) had been working in the bus industry for more than 25 years, demonstrating the long service of these drivers. Drivers worked a variety of different shift schedules, with the majority of drivers working early, middle or late shifts; these were self-selected without specific times due to variation between the operators (see Table 3.4).

Table 3.4: Types of shift driven

Type of shift	Number*
Early	58
Middle	39
Late	32
Night	7
Total	**136**

* Respondents were able to select more than one option

When asked to provide their number of hours worked per week, many found this problematic due to the variable nature of their work, with shifts and overtime liable to change from week to week. The whole numbers provided ranged from 9 hours to 60 hours per week. Where a range of hours was quoted, these varied from '35-40' to '60-72' (37 drivers in total). Of the remainder, four stated '38+' hours, three stated '40+' and one stated '45+'. Four participants did not respond.

3.3.1 Key findings

The focus groups proved to be wide-reaching and informative, with many elements of agreement between the participants. Perhaps most importantly, all of the participants acknowledged that they believe that fatigue is an issue amongst London bus drivers. A small number of participating drivers do not generally feel fatigued, but they recognise it amongst their colleagues. In total 14 themes were identified.

3.3.1.1 Commuting

The focus groups showed that drivers might live a long distance from the sign on point of their bus routes, which is usually a garage or depot. Commuting times of up to one and a half to two hours

each way were quoted by participants (in four focus groups); this was their own commute, or sometimes that of colleagues. This was sometimes due to drivers having moved away from London or might also be a result of the TfL tendering process. This means that, following the tenders going out, certain routes may pass between operating companies and no longer be based near to the drivers' base garage. This can add to commuting times for certain drivers. These long periods of time spent travelling to work are clearly a cause of fatigue, as they informally add to the hours a driver spends on the road. It is clear, however, that commuting by public transport does permit drivers to sleep before beginning a shift; several said that they take advantage of this possibility if they can.

Many routes operate away from the driver sign-on point, so after signing on drivers are required drivers to travel before they begin driving. This is included in the work time and is paid, however, it can be a cause of additional pressure and fatigue to drivers due to trains and/or buses running late.

3.3.1.2 Countermeasures

A variety of actions are undertaken by drivers if they are feeling fatigued whilst driving a bus. These include the commonly undertaken actions of opening the window or getting out of the bus to get some fresh air, taking caffeine supplements and/or drinking (water, hot drink, energy drink), although there was some debate around whether drivers are permitted to drink whilst on duty. Stopping the bus and getting out might not be popular with passengers or controllers, so some drivers noted having invented a possible problem on the bus (back window, tyre, etc) in order to get out at a bus stop and walk around the vehicle and investigate.

The drivers recognised that having a healthy diet and undertaking exercise can both help in countering fatigue, although several noted the difficulties they face through working on shifts. That is, beginning a shift in the early morning or late evening can disrupt eating patterns, meaning that regular meals cannot be taken at the usual time. In addition, it can be difficult for drivers to find time to exercise, given the unsocial hours which they work, the sometimes short periods between shifts, and their family commitments.

Several of the focus groups suggested that having music on the bus would help to keep drivers alert, and noted that they might have had portable radios quietly playing in the cab prior to this being prohibited. Others noted singing and talking to themselves and interacting positively with passengers as a means of avoiding fatigue.

When the bus is stationary during a stand time, one driver reported reading a book and several others noted having a quick sleep (or power nap) to refresh themselves. This has more than once led to a driver oversleeping or needing to be awoken by a colleague or passenger. Another way of resting is to relax, with one driver commenting: "we don't wait until we feel tired before we rest. Any moment we have we just relax, so that the muscles become relaxed as well. Once the muscles are relaxed, they affect the brain, the brain also relaxes. So any time I'm off, I just sit down somewhere and relax … during my breaks, stand times, whatever, I just relax myself."

3.3.1.3 Definitions and understanding of fatigue

In order to reinforce the project definition of 'fatigue', participants were asked to discuss their understanding of the term at the beginning of each focus group. In many cases, their first response was 'tired' or 'tiredness', with one driver stating the following: "over-tired, being over-worked and not having enough sleep, all that sort of thing". Lack of sleep, exhaustion, drowsiness and insufficient rest time were also cited here, with drivers being well aware that good quality sleep is the key to avoiding fatigue. Sleep deprivation was a particular concern, with suggestions that drivers

find it difficult to sleep at unconventional times (e.g. 7.00pm) or may be out late socialising and so will be having a limited amount of effective sleep in advance of shifts beginning.

The drivers also recognised a difference between being mentally and physically tired, although they perceive these to be inextricably linked: “physical and mental, all involved. It’s a concentration of all of the body”. It was also suggested by participants that mental fatigue takes a toll on physical. They noted having to be constantly mentally alert, otherwise the potential for an accident will increase. They suggested that mental fatigue and overload are closely linked to stress and agitation. Participants described fatigue as an impairment of ability and alertness due to the events of day such as grief from passengers, traffic and radio/ controllers. Other drivers mentioned boredom, irritability, being short tempered, losing concentration and slower reaction times.

With regard to physical concerns, participants noted that the body can feel tired through the structure of the cab, the sitting position and an inability to stretch over a long period, making them physically fatigued. Some drivers suggested that mental fatigue is more significant, with physical fatigue being simpler to overcome with certain countermeasures.

Shift work was cited as causing fatigue, with mixed shifts affecting the body’s systems due to severe changes in start and end times, or to beginning and finishing work in the dark. The repetitive nature of some shift patterns was also discussed in the context of fatigue.

3.3.1.4 Facilities

A lack of suitable facilities was often cited by drivers as a cause of fatigue. For example, some operators have organised break times at bus stops rather than stands or garages. This can often mean that drivers are compelled to rest and eat on the road, rather than in a warm and sheltered place where they can sit and relax. If they go to a café or restaurant, they will have to pay and may not be able to find healthy food. Where there is no canteen at a changing point it is often necessary for drivers to commute to a place to find food, and eat a heavy meal causing feelings of drowsiness when returning to drive again.

Canteen facilities are provided at many garages and depots but are likely to have limited opening times and will not necessarily be open during early or late shifts. Furthermore, participants claimed that the canteens they do have are unlikely to offer healthy food. In other places, microwave ovens are available, but often shared amongst a large number of people making it difficult to gain access during a standard break.

A general lack of rooms in which to rest at the garages and depots was also cited as a barrier to being able to relax and perhaps sleep before shifts and during breaks (including those which are part of a spread-over shift). Participants clearly believe this to impact on fatigue levels.

Taking breaks on the road draws attention to another problem whereby drivers do not have access to toilet facilities. This causes worry to drivers who may consequently not drink sufficient liquid for fear of needing to urinate whilst not having access to these facilities. In addition, two of the female participants noted not having easy access to a bathroom during their menstruation period. However, it should be noted that TfL are currently running a project which will provide a minimum of 41 new toilet facilities for drivers on routes which do not currently have toilet facilities available.

Drivers are aware of the positive effects of exercise, both for general health and in helping to avoid fatigue. To this end, they would like their employers to provide exercise equipment at work or discounted access to a local gym. They also noted that shower facilities would aid in them cycling or

running to work as a means of exercising. It should be noted that some operating companies already provide such facilities, which was positively described by the relevant participants.

3.3.1.5 Money

Budgetary concerns are an important matter for the drivers. They suggested that pay rates are insufficient due to monetary pressure on the operating companies and many drivers take on overtime to make up for the shortfall. As noted by both bus drivers and their managers, there is currently a shortage of drivers which provides ample opportunity for overtime. This then has an effect on their rest times and can mean shorter periods between shifts, getting close to the legal regulations. It can lead to drivers suggesting that they drive only for the money, rather than for passion about driving and the interaction with passengers inherent in working on a bus. In addition, participants at several operating companies believe that drivers are earning differing pay rates, which may be due to variations in driving experience, or to operators taking over other companies and inheriting drivers on alternative pay scales. These differences in pay may cause feelings of unfairness and irritation. It should be noted that a recent TfL initiative (Licence for London) aims to enable bus drivers to move employer whilst receiving a similar rate of pay to colleagues with comparable lengths of service.

3.3.1.6 Other road users

A key source of mental fatigue for the participants is other road users and the road furniture which they encounter. Of particular note is the volume of traffic on certain routes, which causes the drivers to deviate from the schedule, leading to complaints from passengers and interventions from the controllers. It also means drivers are required to employ a greater level of concentration and attention to the road. It was also noted that traffic will increasingly be a problem as a greater number of vehicles appear on the road, there is an increase in shared cycle pavements, trucks and vans delivering, and people walking in the road, stepping out too close to the edge.

Cyclists were also cited as a cause of mental fatigue for drivers, particularly where they do not use the dedicated cycle lanes but ride “slowly” along the bus lane. One driver stated that cyclists riding in front of them were adding to their stress by forcing them to drive more slowly. This was a particular annoyance to them as they considered that similar behaviour on the part of the driver would see them reprimanded and/or fired. One participant reported that the erratic riding of a cyclist has caused a them to brake hard, causing one of their passengers to fall over and leading to the driver feeling stressed. It was reported that cyclists may also feel intimidated by buses, becoming scared and attacking drivers through their window or breaking their mirror and riding away. The drivers reported this as a cause of mental fatigue, indeed one focus group was clear that cyclists were perceived to be the biggest cause of fatigue for them. However, another driver noted seeing “good cyclists and … bad cyclists”.

Drivers also brought up issues about the road furniture and parking practices, noting the large size and slow brakes of the bus. They suggested stress and fatigue can be caused when attempting to manoeuvre around the London roads.

3.3.1.7 Reporting fatigue

The study is investigating how fatigue and sleepiness are managed at work, and to this end drivers were asked about their experiences of reporting fatigue. The majority of participants know how to report fatigue, but many are unsure of how this would be handled by managers, and few have ever reported feeling fatigued. A small number of drivers were comfortable with reporting fatigue, and had experience of doing so, citing their worries about the safety implications of carrying on working while tired. Others believed that they would face discipline if they admitted to feeling tired and

suggested they would be more likely to call in sick in such a situation. In these cases there was generally a reluctance to being assessed by the operator, and potentially being offered medical support. Participants suggested that they were 'not allowed' to be tired and were unlikely to discuss fatigue either with managers, supervisors, or other drivers. This demonstrates a perceived lack of support from the operator around fatigue, suggesting a closed culture around the subject, with drivers suggesting managers do not understand their working roles.

Some participants had received advice on combating fatigue and others reported having a company handbook containing such information; this was considered to be insufficient and was often in the form of posters which are thought to be ineffective. They also suggested that this information is often not new to them, but instead provides solutions which are unrealistic for them on an everyday basis. For example, the advice may cover healthy eating, but shift work and a lack of a canteen or choice of eating place make it difficult to have such a diet.

There was a general awareness of new computer fatigue monitoring technology which is being piloted at the current time. Drivers were generally apprehensive about these, but none had sufficient experience of them to give a robust opinion.

3.3.1.8 Shift patterns

The focus groups showed that shift patterns are a significant issue for bus drivers in the context of fatigue. Where they saw problems within their shifts, the drivers had a variety of suggestions for what they considered to be more effective working patterns. There was also a general wish for shorter hours with better pay, which it was thought would lead to a reduction in fatigue.

As a result of the wide variety of shifts being offered by the companies and being undertaken by the drivers, it is difficult to consider all of these within these findings. However, there follows a consideration of the key issues which were discussed.

Participants commented on the difficulties of their shifts changing from week to week. For example, on a regular rota one week might be early shifts, the next middles and the next late shifts. Some of the drivers noted that their body clock becomes used to a certain sleep pattern for one week and then quickly has to change sleep pattern – they find it hard to adjust. This then affects eating (maybe having lunch or breakfast at 10:00). The next week the shift might begin at 16:00 and lunch will be at 19:00 or 20:00, necessitating a change in body clock every week. In addition, having a week with very early morning shifts will cause cumulative sleep deprivation and fatigue. This is in line with the results of the on-road study in terms of sleep duration.

Some drivers are permitted to work on one shift pattern, for example, an early shift which allows workers to finish in time to collect their children from school. Participants on these types of shifts tended to be those with young children, or those with long service who participants saw as having 'earned' the right to such a dispensation. Some drivers drive night shifts only, although these were thought to be particularly fatiguing by the focus group participants who sometimes drive the bus at night. It should be noted that there were few night drivers participating in the focus groups because these all took place during the day when night drivers are inevitably not on duty. Other drivers noted that only a small number of drivers are usually permitted to work on one shift and that it is therefore difficult to become one of those.

There were participants working as 'spare' or standby drivers; these cover shifts when the usual drivers are on leave or sick. Some noted enjoying this way of working, suggesting that it avoids the monotony of driving the same route all the time. However, due to the nature of the role, notice of the hours to be worked may be only 24 hours (the minimum period) in advance. This, and the

difficulty of changing shift every day, can make other aspects of the driver's life difficult to plan, particularly in terms of healthy amounts of sleep. Sudden shift changes are stated as a source of fatigue and stress for all the drivers, not just spares (who anyway represent a very small percentage of the driving population in any garage).

The drivers were all knowledgeable about the legal limits of driving, and most companies had a driver portal or other computer software to inform drivers of their shifts and allow them to check their hours are compliant. This was very important when swapping shifts; the arrangements were routinely left to drivers to decide between themselves but then checked by a scheduler or manager before being made official. All operating companies allow drivers to swap shifts within the legal limits. The portals and scheduling also mean that drivers can potentially be aware of their future working hours up to a year in advance.

Overtime is an integral part of shift patterns, with drivers similarly knowledgeable about how this fits in with their other driving duties. Within the legal limits it is possible to drive 13 days out of 14, of which some of the participants have experience. This necessarily cuts down on rest periods; some drivers commented on these not being long enough in terms of sleeping sufficiently well.

There is a general shortage of part-time bus drivers, with some companies having none at all. The focus group participants suggested that a greater number of such workers would reduce fatigue, and perhaps attract a greater number of people to the profession; this was felt to be necessary given the current shortage of drivers in London.

Overrunning shifts were cited as a particular cause of fatigue, where a driver might be delayed significantly due to traffic and/or diversions. This can then reduce meal relief periods. Drivers are concerned when they lose stand time and when this is curtailed or even cut due to the short turnaround times which are sometimes a result of the current pressure on the schedules or unexpected delays (caused, in part, by buses and routes being taken out of service). They also see an increasing pressure to arrive early to work (often unpaid) in order to check the bus before departure, demonstrating a need to maintain buses to ensure they are always kept in a suitable condition.

'Spread-overs' (12-hour shifts which include a 3 to 4-hour break in the middle) have formerly been common, however the focus groups showed that a relatively low number of the operating companies currently utilise these. Drivers noted earning more for such shifts but finding them fatiguing when having to stay at the garage or depot during the break or as a result of the extension of work time and shorter periods away from work overnight. It is notable that such drivers stated they would be likely to sleep during these breaks if the appropriate facilities exist.

3.3.1.9 Sickness

The theme of sickness was clear throughout the focus groups, with examples cited of fatigue and stress causing drivers to be unwell (depression, heart attack, stroke, obesity etc.). It was also suggested that fatigue weakens the body so that drivers are more susceptible to colds and other more minor ailments. Unhealthy eating patterns were also believed to be a cause of some of these illnesses and fatigue. One participant had experience of sleep apnoea, which had been medically managed in conjunction with the operator, enabling them to continue driving.

In all of the operating companies the responsibility is on drivers to declare their fitness to work when signing on for duty. This may be in a variety of ways and is more explicit in some companies than others. Drivers were all aware of how to report in sick but were wary of doing so due to strict rules surrounding absences from duty. This is related to having to speak to a manager if absent three times within a circumscribed period, with a note being added to the driver's personal file. The

participants did not see this as a means of discussing any problems they might have but were more concerned about what they see as a disciplinary procedure.

One focus group was vocal about requiring a greater level of welfare support. This had been provided to them in the past, and they believe it would be a valuable support in discussing and managing their fatigue.

3.3.1.10 Sleep

As noted elsewhere, effective and sufficient sleep is recognised by the participating bus drivers as key to avoiding tiredness, and they recognise the differences and links between mental and physical fatigue. There were widespread examples of feeling tired or drowsy whilst driving, with varying severity, as far as to name instances of drivers falling asleep or having microsleeps whilst at the wheel. This is not common but has happened.

Participants acknowledged a difference in their driving when fatigued and the key effects were: speeding up, driving erratically, driving on autopilot, longer reaction times, failure to think and plan ahead, losing concentration, and driving aggressively. Drivers were aware of the possibility of making a simple mistake and causing an incident due to fatigue. A clear link between tiredness and collisions was recognised by the participants. In addition, fatigued drivers might become miserable, not smiling or wishing to speak to the passengers.

Some drivers noted having difficulties relaxing and sleeping in between shifts and had experiences of falling asleep at home when undertaking a different task.

3.3.1.11 Stress, workload and frustration

As noted above, drivers linked 'stress' (by their own definition) and fatigue during the focus group discussions, with some mentioning stress when asked to define fatigue. They named the following as significant causes of what they would describe as stress:

- The monotony of driving the same route; some have altered their shifts in order to vary the routes driven
- Passengers lacking respect for the drivers, complaining about the late running of the bus, not acknowledging the driver, not paying for their journey, making (unjustified) complaints after travelling on the bus
- School children – mentioned particularly as challenging and stressful for the drivers due to riding on the bus in groups and incessantly pressing the stop button
- Radio and controllers– the communication between the radio controllers and the bus drivers can be problematic, with drivers complaining about the tone sometimes used to give them information/instructions. The drivers believe that the majority of the controllers have not been employed as drivers and are therefore not empathetic; it is likely that this is an inaccurate assumption. Requests made by controllers (wait for five minutes, terminate the bus) cause passengers to blame the drivers. The condition of the radio can also be bad and therefore distracting and stressful
- Internal and external monitoring including 'mystery travellers' and the Best Customer Experience survey which they see as adding further duties (e.g. pulling up to the stop properly, greeting all passengers) when driving in often demanding situations
- A lack of support from their employer, e.g. feeling unable to report fatigue and two participants (in different focus groups) noted receiving a letter at the beginning of their shift requesting they have a meeting with a manager; they subsequently dwelt on this for the remainder of their duty

- Other road users (see 3.3.1.6)
- Threats and violence from those inside and outside of the bus, that is, being abused by the public, vulnerability of opening the cab window, using the safety screen as a deterrent but then finding it a barrier to interaction with passengers
- Information overload – having to concentrate on passengers, the traffic situation and the controllers all at one time
- The physical environment, that is, the condition of the bus itself, the physical discomfort of driving a bus, and experiencing a problem with the bus before leaving the depot
- Having had an incident whilst driving the bus, some drivers find it very difficult to forget about it
- The pressure and difficulties of meeting the route timetable which is often unrealistic

The drivers' methods of avoiding stress and relaxing were socialising with colleagues, exercising and practising methods of staying calm. A dedicated stress policy at operating companies was noted as a potential benefit.

3.3.1.12 The occupation of 'bus driver'

The focus groups were notable for raising some specific issues related to bus driving as a specific and distinctive occupation. Several of the groups believe that bus drivers are key workers, keeping London moving and working, particularly when other public transport is not available. For example, bus drivers notice a difference when underground train workers are on strike, and they are required to act as a replacement and take on a greater volume of passengers. Furthermore, participants compared themselves with underground drivers, suggesting that driving a bus is a more complex occupation, which involves a far greater level of interaction with passengers and lower levels of pay. Some stated a wish to become employees of TfL, in a similar manner to underground drivers. A more active union was cited as being required to aid in an improved working situation for bus drivers. Some participants had been employed to drive a coach or truck and claimed that working on a bus is more fatiguing. However, the participants were also often positive about their jobs, saying that they carried on as a bus driver due to an enjoyment of, or even passion for, driving. Others noted enjoying the interaction with people, which they prefer to an office job.

The theme of bus driving being a specific activity was widely discussed, with suggestions that drivers are taking on a greater number of duties and becoming operators rather than simply drivers. Indeed, the notion that bus drivers hold a high level of responsibility was universally understood, with participants noting their heightened feelings of accountability for other people's safety whilst driving a heavy vehicle full of passengers. There was also a constant feeling of being responsible for delivering a service to the public which they want to continue without being subject to delay.

All of the focus groups noted a lack of respect for bus drivers; this relates to stress received from dealing with passengers and, to a certain extent, cyclists. Participants felt the need to note that drivers are people with feelings, with one group going as far as to suggest a public education programme on not stressing (and therefore fatiguing) drivers. The drivers suggested that they would like their situation to be understood by managers and to take into consideration that "we are human beings, we have a body clock, we have families." Participants therefore sometimes have feelings of loneliness through a lack of social contact, both from being ignored and/or disrespected by passengers and due to working unsocial hours. Individual differences between driver personalities was discussed in relation to this, with some feeling more fatigued than others by disagreeable or indifferent passengers.

The policy review completed for this research showed that the ratio of females amongst London bus drivers is currently approximately 10%. Female participants stated that this can present difficulties for women drivers in that they feel a lack of companionship and difficulties in discussing any issues particular to females.

As noted above, there were participants in the focus groups who had a long history working as bus drivers and some of these compared their current working lives with their past situation. A strong feature of these comments was a feeling of nostalgia, whereby they felt that their past experience was more positive than their current circumstances.

3.3.1.13 Time of the day

There was a range of times at which drivers reported being most likely to feel fatigued. There were as follows: at the beginning and the end; in the middle; coming towards the end; after a break having eaten; the first day back after rest days; at the weekend; at rush hour; sitting around during spread-overs and early jobs that begin around 3.00am. Several of the drivers noted that they have shifts during which their break is early into the shift, meaning that the second half is comparatively much longer (2.5 hours/5.5 hours) – they feel particularly fatigued during the second half. Longer and busier routes were also reported to lead to greater levels of tiredness.

3.3.1.14 Work life home life

Drivers discussed the difficulties of balancing their work and home life, and how this can lead to feeling tired. For example, drivers interested in overtime can be contacted by their employer whilst at home and this can often interrupt them whilst they are actually asleep. This is clearly not ideal for effective sleep patterns.

Many of the participants discussed family and social commitments as important contributors to fatigue. They noted that their non-working time is often taken up with the needs of their families, causing them to miss out on rest, relaxation and sleep time. This may be due to children, spouses and parents requiring their attention. It is particularly striking that drivers may have only a 10-hour period between shifts, during which they must, for example, travel between work and home, cook and eat some food, relax, spend time with their family and, most importantly, sleep. Many participants noted finding this problematic. This was also true when considering social commitments which might cause drivers to stay up late, therefore lacking sufficient sleep for a subsequent shift. This was particularly the case for younger drivers.

Various methods of relaxing at home after work were noted by the participants, most importantly a recognition of the importance of sleeping. Other methods were spending time with the family, watching television, playing computer games, cleaning, watching horror films, and not thinking or talking about their work. These are ways the drivers find to help them have a healthy sleep pattern. The discussions also found that some drivers experience difficulty relaxing between shifts, which may lead them to have insufficient or poor sleep.

Methods of relaxing before work included arriving as early as possible and socialising with colleagues, relaxing and eating in the canteen, watching the television, and trying not to get stressed by doing something they enjoy. Others suggested they simply get themselves ready, drink some coffee and go.

3.3.2 Summary

In summary, the focus groups demonstrated the following:

- Fatigue is a problem amongst participants in the focus groups, with all of the participants having experience, or being aware of others having experience of sleep-related incidents whilst driving a bus
- Drivers are unlikely to discuss fatigue amongst themselves, or with their managers and generally avoid reporting it, preferring to report in sick
- Levels of overtime are high amongst London bus drivers, mainly cited as being a response to low levels of pay; opportunities for overtime are great due to the current lack of drivers
- Family and social commitments contribute to levels of fatigue amongst participants in the focus groups
- Shift patterns are believed to be a key issue in fatigue; this includes rota patterns, scheduling and break length
- A general lack of facilities (including for breaks) is a concern for the bus driver participants
- Bus drivers recognise the responsibility inherent in their job, but also see a lack of respect for their role amongst those with whom they interact
- Stress is seen as a cause of fatigue by the participating bus drivers; stressors include passengers, other road users (including traffic), monitoring and the condition of vehicles

3.4 Task 4: Manager interviews

All ten of the London bus operating companies nominated managers suitable to be interviewed in relation to fatigue management. That is, a person who would respond if a driver reports feeling tired, or if a driver has an incident appearing to be caused by fatigue/sleepiness. In total, 11 one-to-one telephone interviews were conducted by the same researcher (two individuals were involved from one operator; one at each of the remaining nine operators). Of the 11 interviewees, 10 had previously worked as a bus driver before becoming a manager.

3.4.1 Key findings

The interviews showed that the managers have a greater understanding of the drivers than the drivers in the focus groups think; this empathy is likely to be due to the fact that the majority of interviewees had worked as a driver earlier in their career. Managers are in some ways caught in the middle between drivers and the needs of the operator because there is a requirement to keep the buses moving and to guard the operator's reputation. To the managers, fatigue is a safety issue and they feel the responsibility to make sure it is not having an adverse impact on the business or risking people's lives. From the management perspective it is necessary for supervisors and managers to know how to spot the signs of fatigue and question it and challenge it and make sure the people who are driving their buses are fit to do so. On the other side there is a need to make sure the staff are aware of fatigue issues and that they are actively managing it themselves taking into account their sleep patterns and what they do during the day and what they do before and after. Therefore, drivers have the responsibility to manage their fitness but also their fatigue levels. There is an understanding amongst managers that bus driving is a responsible job which drivers should take seriously because it is a safety critical role.

There was a general recognition that fatigue is a concern amongst London bus drivers, and all of the interviewees had seen examples of it being a contributing factor to incidents on the road. The extent to which fatigue is a problem was disputed amongst the managers interviewed, but not all were as involved in investigating incidents and/or fatigue as others. In addition, it is notable that managers commented on suffering from fatigue themselves, and utilising similar countermeasures to those discussed by the drivers.

As might be expected, individual differences exist between the managers in terms of how understanding they are about the fatigue which bus drivers exhibit, and how approachable they aspire to be. Several of the managers raised the subject of random testing for drugs and alcohol, when asked about how they ensure their employees are fit to drive, although they recognised this was not necessarily an indicator of fatigue. One manager noted informing drivers that being awake for 17 hours can impair performance to the same degree as two units of alcohol as a means of explaining the impact of fatigue.

Overall, seven of the 14 key themes identified in the focus group analysis were discovered in the manager interviews.

3.4.1.1 Commuting

None of the operating companies have a policy or restriction on commuting distance to work, and managers are aware that some drivers have a long journey before they sign on for duty. They are aware that this can add to fatigue and some mentioned either speaking to employees about this or monitoring those to whom it applies.

3.4.1.2 Definitions and understanding of fatigue

In order to reinforce the project's definition of 'fatigue', the managers were asked to explain their understanding of the term at the beginning of each interview. The first response was generally 'tired' or 'tiredness', with the added suggestion of "tiredness to the point of feeling drowsy, you want to go to sleep." Monotony caused by heavy traffic, lack of sleep and the time of a shift were also mentioned here. The interviewees also connected feelings of moodiness, agitation, difficult passengers and stress to fatigue. However, they found it difficult to suggest any other potential causes of fatigue.

In common with the drivers, the managers understood the difference (and links) between physical and mental fatigue. They were more likely than the drivers to link tiredness explicitly with lack of concentration, crashes and falling asleep at the wheel.

3.4.1.3 Money

The managers all discussed having a shortage of drivers, leading them to offer relatively high levels of overtime to existing employees. They generally realise this could be leading to drivers taking on too much work, but their responsibility to the operator and knowledge of driver's own wishes outweigh those concerns.

Another reason for overtime cited by the interviewees was the low levels of pay that drivers experience. They see this as a result of the tendering process in which companies endeavour to keep costs as low as possible. Drivers will therefore take on extra duties to make up their money. Two of the managers also suggested that the current low rates of pay are attracting people who are not particularly suitable to act as drivers.

3.4.1.4 Reporting fatigue

Managers all place the emphasis and responsibility on the drivers to ensure that they are avoiding fatigue. They state that companies are eager to support drivers in their efforts in this area but cannot force them to take the appropriate measures. However, all of the managers were positive about trying to help and support drivers if they report fatigue; the frequency of reporting was not discussed in detail. They try to be approachable and open, desiring an open culture around tiredness issues, although all noted that the operators could be more proactive in their efforts to highlight fatigue and promote a greater level of openness around the subject. Moreover, managers recognise

that the drivers are reluctant to report fatigue, fearing disciplinary action. They believe that drivers will either continue working although fatigued, or report in sick rather than admit to tiredness.

An example of this willingness to be supportive came from an interviewee desiring information from the research study to help in these endeavours. Information requested related to the least fatiguing kind of shift patterns in order to offer these to drivers, and examples of advice that could be offered to drivers for reducing fatigue. One manager had put together a handout and presentation on their information screen for drivers because awareness of fatigue had been raised by some incidents. This was intended to educate drivers on the risks of fatigue and how to manage it. Another manager had been doing some research of their own about driver fatigue.

The emphasis is also on drivers to report fatigue so that they can receive help. In an incident which was found to be due to fatigue, a driver who had not reported tiredness would be more likely to be disciplined and sacked.

The managers also discussed the difficulty of proving tiredness in an incident. In all companies there are investigations of incidents, with procedures and questions asked, including some related to sleep, shift patterns, overtime and fatigue. In addition, many of the managers were responsible for watching recordings of drivers in incidents. Some had gained a knowledge of the signs of potential fatigue but noted it can be impractical to be sure that it has been in play.

3.4.1.5 Shift patterns

It was widely acknowledged by the interviewees that shift patterns can be a major cause of fatigue, especially when considered alongside the elevated levels of overtime being undertaken. Some of the solutions offered by managers are as follows:

- Overhauling and altering rotas in response to drivers reporting fatigue
- Accommodating driver requests by attempting to arrange shift patterns around the preferences of employees
- Instituting longer rest periods between duties than are stated within the legal limits – this is a company-wide initiative in one instance
- Putting drivers on one shift pattern (‘constant shifts’) to help when they report fatigue
- Putting drivers on a more stable shift pattern when they report fatigue
- Allowing drivers to swap shifts for a period (usually 2-3 months) to alleviate monotony

One manager noted that they believe the operator’s safety and scheduling teams are not working together to the extent they could. This might aid in the creation of safer shift patterns.

3.4.1.6 Sickness

The interviewees had encountered a variety of health issues related to their drivers. More generally, some managers noted finding it unhealthy to be working long hours (e.g. thirteen days as is legally permissible) and cited it as a big problem in terms of the health of the drivers.

When the drivers tell them about insomnia or other sleeping problems the managers report being able to involve occupational health and medical staff and ensure their shift patterns are appropriate, e.g. avoiding early starts and focusing on later shifts. This helps to ensure drivers are getting the appropriate rest and sleep. Medical intervention may also reveal other underlying health issues such as sleep apnoea; examples of which most of the managers had encountered. Driver health is utmost with the managers who want to ensure they adopt a healthy lifestyle through resting when not at work, getting plenty of sleep and having a healthy diet.

3.4.1.7 Work life home life

The managers recognise drivers have a life outside of work and noted that family and other commitments are likely to affect their ability to have sufficient sleep and are therefore a contributory cause in levels of fatigue. They also acknowledge that the younger drivers may have social commitments which also reduce their levels of sleep.

3.4.2 Summary

In summary, the manager interviews demonstrated the following:

- The interviewees recognise fatigue as a problem amongst the drivers they supervise and they understand the links and differences between mental and physical fatigue
- Many of the managers interviewed demonstrate a wish to make fatigue a more acceptable subject to discuss and would welcome a more open culture around this subject
- Given their understanding, managers are agreed that the responsibility lies with the drivers to manage and report their own fatigue
- Managers are making attempts to mitigate against fatigue by responding to the needs of the drivers when fatigue is reported to them
- Managers have a responsibility to drivers and the needs of the company; to the managers, fatigue is a safety issue and they feel the responsibility to make sure it is not having an adverse impact on the business or risking people's lives
- Managers recognise the other pressures on the drivers outside of the work context

3.4.2.1 A comparison of the findings of the bus driver focus groups and the manager interviews

In comparing the findings from the driver focus groups and manager interviews the following similarities and differences were observed:

- Participants in both the focus groups and interviews are agreed that fatigue is a concern for London bus drivers. They have a similar level of understanding of mental and physical fatigue, and on the ways in which these manifest
- There were differing views on reporting fatigue, with managers wishing to be open and approachable so that drivers can feel comfortable in talking to them about being tired. Conversely, drivers generally would avoid reporting being fatigued, fearing disciplinary consequences
- It could be argued that the managers are more apt to understand the perspectives of the drivers than the drivers are to be understanding about the views of the managers
- There is agreement across the two work roles that shift patterns are a key cause of tiredness, and that these might therefore be improved
- Managers and drivers both agreed that overtime is contributing to levels of fatigue, but both had their own reasons for seeing a necessity for it currently
- It could be argued that managers would benefit from a greater knowledge about the causes of fatigue, particularly in regard to the lack of facilities, as this was commonly mentioned by drivers but not by managers. That is, when the interviewed managers were asked what contributes to fatigue, they were less likely than the drivers to discuss the lack of facilities
- It was clear that the first concern of managers is safety and they were therefore more likely than the drivers to link tiredness explicitly with lack of concentration, crashes and falling asleep at the wheel

3.5 Task 5: Driver survey

3.5.1 Key findings

This section discusses the key findings obtained from the bus driver survey. In total, 1,353 drivers completed the survey (85% male). Drivers were aged between 20 & 73 years, with an average age of 45 years, and had been driving a bus for an average of 10 and a half years. Approximately 46% worked on fixed rotas, and 52% worked on rotating/ mixed rotas. Drivers reported working between 8 and 75 hours per week (average of 44 hours per week). On average, drivers reported needing 7h 55m (*SD* = 1h 8m) sleep between shifts to be able to drive safely and feel rested. However, they usually got an average of 6h 30m (*SD* = 1h 20m) sleep between shifts.

At least one driver from each of the 10 London bus operators responded to the survey. However, it should be noted that 1,353 drivers is a small proportion of all London bus drivers (total = ~25,000). A full list of results obtained in this survey can be seen in Appendix I.

3.5.1.1 The extent and nature of fatigue in London bus drivers

The first set of results address the research question "what is the extent and nature of fatigue in London bus drivers?". The results from the survey show that drivers do experience sleepiness and fatigue whilst driving the bus. 79% of drivers who responded to this survey believe that their working hours lead to sleepiness whilst driving the bus. A large percentage of drivers indicated that they experienced signs of sleepiness such as yawning (89%), frequent eye blinks (53%), and difficulty concentrating (41%) whilst driving the bus (see Figure 3.2).

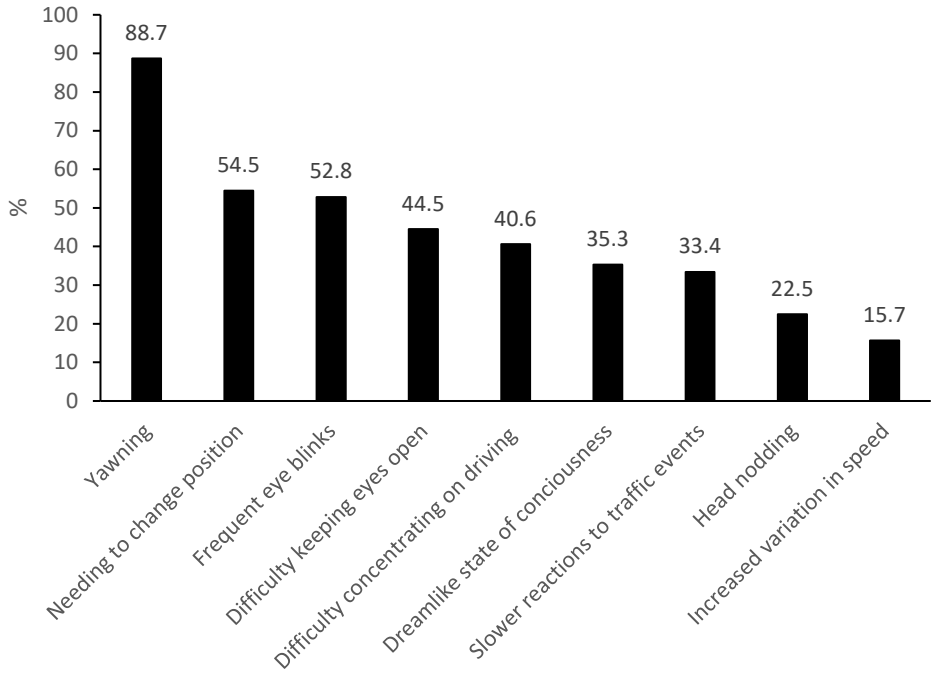


Figure 3.2: The percentage of respondents who said they showed signs of sleepiness whilst driving the bus. Respondents were able to select more than one option.

When looking at the effects of sleepiness and fatigue whilst driving, approximately 17% of drivers indicated that they had fallen asleep whilst driving the bus at least once in the past 12 months (see Figure 3.3).

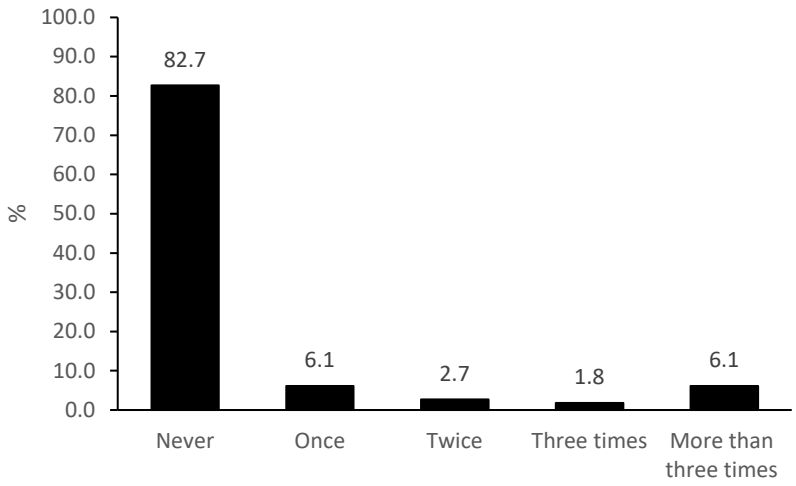


Figure 3.3: Frequency distribution for "In the past 12 months, have you fallen asleep whilst driving the bus?"

When asked if they had experienced a road crash or a close call in the past 12 months due to fatigue, approximately 5% of drivers reported being involved in a road crash at least once, whilst approximately 36% of drivers reported having at least one close call in the past 12 months (see Figure 3.4). Operators and TfL are likely to be unaware of the effect of fatigue and sleepiness in these circumstances because 77% of those who had experienced a road crash believed their employer did not know the incident was due to the driver feeling sleepy. A similar result emerged amongst drivers who experienced a close call, with 88% indicating that their employer would not know the incident was due to them feeling sleepy.

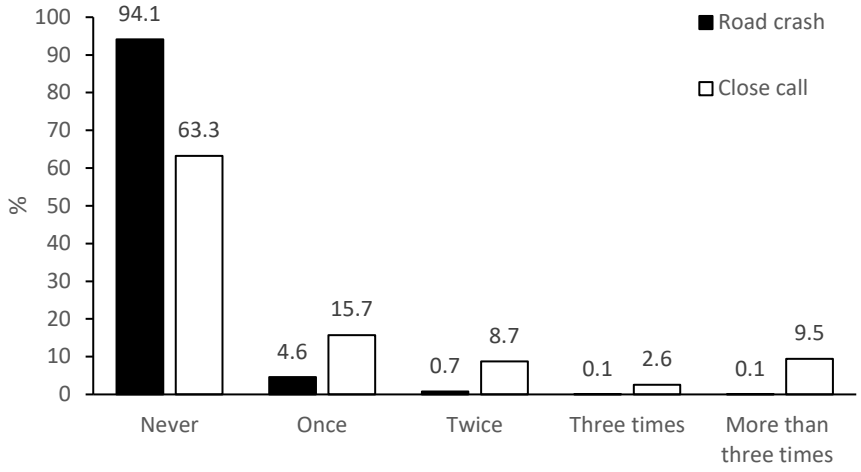


Figure 3.4: Frequency of drivers reporting being involved in a road crash or close call in the past 12 months because they were sleepy.

Further evidence to suggest that bus drivers experience fatigue can be seen in the responses to questions relating to stopping the bus due to fatigue. Drivers were asked if they have had to stop the bus due to fatigue in the past 12 months, and if they had wanted to but were unable to. The results showed that whilst 78% of drivers had never had to stop the bus, more than half (55.5%) had wanted to at least once, with 28% of drivers wanting to stop the bus due to fatigue more than three times in the past year (see Figure 3.5).

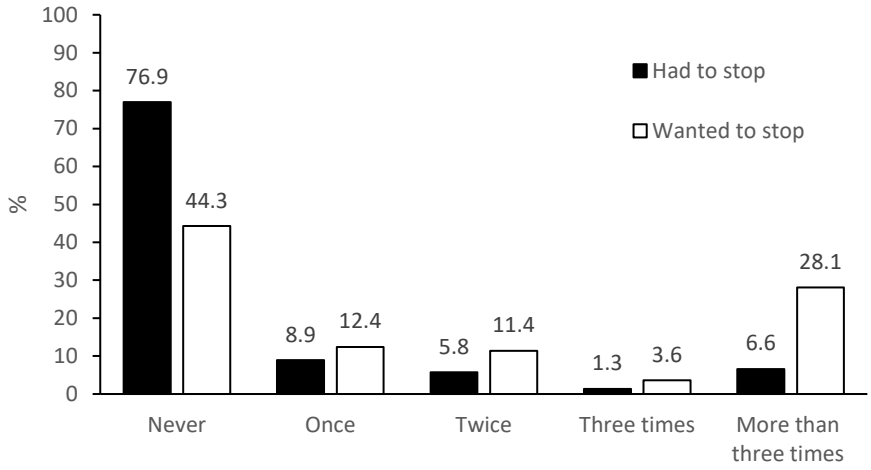


Figure 3.5: Percentage of drivers stating that they had to or wanted to stop the bus in the past 12 months due to fatigue.

In response to the question "how often do you have to fight sleepiness in order to stay awake while driving the bus?" 21% of drivers indicated that they have to fight sleepiness at least 2-3 times a week (see Figure 3.6). This result was similar to that of the Swedish survey by Anund et al. (2016) who found that 19% of drivers had to fight sleepiness at least 2-3 times a week. The variable of having to fight sleepiness was related to several variables referring to sleepiness/ fatigue related incidents on the road. Results showed that having to fight to stay awake at least 2-3 times a week was a significant predictor of falling asleep whilst driving the bus with those who had to fight sleepiness being 5.5 times more likely to have fallen asleep whilst driving at least once. Those who had to fight sleepiness were also 6.5 times more likely to have had a close call, and almost 3 times as likely to have had a road crash in the last 12 months. They were also twice as likely to have had a sleep related incident in the last 10 years. These results were obtained from conducting a series of univariate logistic regressions.

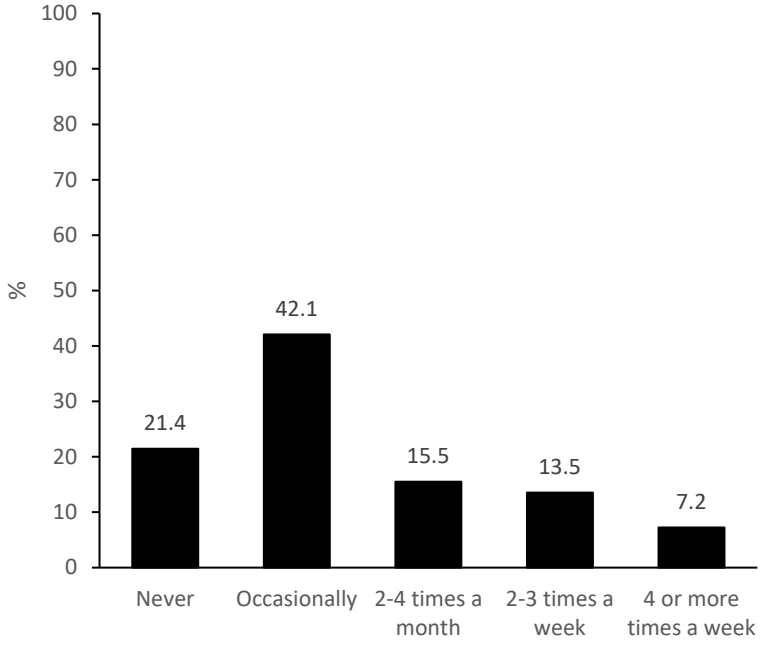


Figure 3.6: Frequency distribution for "how often do you have to fight sleepiness to stay awake while driving the bus?"

3.5.1.2 The key causes of fatigue in London bus drivers

This section addresses the research questions "What are the key causes of fatigue?" and "Are there patterns of working, demographics or any other factors that are correlated with fatigue in London bus drivers?" From the survey results it is possible to identify which factors are statistically associated with driver fatigue/ sleepiness. In order to achieve this, drivers have been grouped according to two criteria. Those in the first group had to fight sleepiness whilst driving the bus at least 2-3 times a week (*n* = 281), and those in the second group did not (*n* = 1069). For the second criteria, those in the first group had experienced a sleep related incident in the last 10 years (*n* = 227), and those in the second group had not (*n* = 1076).

Statistical analyses were used to first determine whether individual variables were able to predict whether a person would have to fight sleepiness, and whether they had a sleep related incident in the last 10 years. The variables used in these analyses were split into three categories: (1) sleep related factors, (2) work related factors, (3) health related factors. The analyses can be seen in Appendix J. Predictors which were found to be statistically significant were then entered together into a further analysis to establish which factors were the strongest predictors of either having to fight sleepiness or having a sleep related incident.

Several factors were found to be significant predictors of whether or not drivers had to fight sleepiness at least 2-3 times a week. In relation to sleep, scoring highly on any of the sleep indices was a strong predictor, with those scoring highly being significantly more likely to have to fight sleepiness than those who scored lower. Another strong predictor was having a sleep condition, with those who had a sleep condition being three times (200%) more likely to have to fight sleepiness than those without a sleep condition (with the majority of those reporting a sleep condition reporting obstructive sleep apnoea). Not obtaining enough sleep was a strong predictor or having to fight sleepiness, respondents who reported not getting enough sleep before their shifts were three times (200%) more likely than those who reported getting enough sleep. Respondents who snored were 85% more likely to have to fight sleepiness. Self-reported sleep quality was also a significant predictor, with those reporting good sleep quality being 80% less likely to have to fight sleepiness than those who reported poor sleep quality. These results were similar to those obtained in the Swedish bus driver survey by Anund et al. (2016), where scores of each of the five sleep indices, snoring, and obtaining enough sleep were al found to predict having to fight sleepiness. Previous work by Kim et al. (2018) has also shown that having a sleep disorder significantly predicts driver fatigue.

Work related factors were also found to influence whether drivers had to fight sleepiness. Those who had less than 11 hours' break between shifts were 45% more likely to have to fight sleepiness, whilst those who reported working for more than 6 consecutive days without a rest day were 80% more likely. Drivers receiving short notice of shifts were 60% more likely to have to fight sleepiness, and drivers who experienced variability in start times were 80% more likely. The amount of stress experienced whilst driving the bus was also a significant predictor, with drivers who rated their stress as higher being 30% more likely to have to fight sleepiness. Commuting was an important factor, and results showed that those who had longer commute times were slightly more likely to have to fight sleepiness, whilst those who commuted using public transport were 25% less likely than those who did not. One work related factor which was not found to be a significant predictor of having to fight to stay awake was whether the respondents worked rotating or fixed rosters.

Two of the strongest predictors of having to fight sleepiness were specifically related to break times at work. Drivers who reported having insufficient time to eat were twice as likely (100% more likely) to have to fight sleepiness than those who reported having sufficient time. Whilst drivers who

reported having insufficient time to rest during their break were more than twice as likely (170% more likely) to have to fight sleepiness than those who reported having sufficient time. Another significant predictor related to breaks at work was having somewhere to sit, drivers who were not provided with somewhere to sit during their breaks were 65% more likely to have to fight sleepiness than those who reported having access to somewhere to sit.

One final work related factor which significantly predicted not having to fight sleepiness was enjoyment from bus driving, with those who stated that they drove for enjoyment, as opposed to just for payment, being 20% less likely to have to fight sleepiness.

In terms of health factors, self-reported health was a strong predictor of having to fight sleepiness. Compared to those reporting good general health those reporting their health as neither good nor bad were 80% more likely, whilst those reporting poor health were over three times (230%) more likely. Those who indicated that they had experienced higher levels of stress over the last 3 months were 30% more likely to have to fight sleepiness. Those who smoked were also 40% more likely to have to fight sleepiness. Neither BMI, nor level of exercise were found to be significant predictors of having to fight sleepiness.

Age was also a significant predictor such that drivers in their 20s were more likely to have to fight sleepiness. In comparison, drivers in their 40s and 50s were 50% less likely, whilst those aged between 60 and 73 were 60% less likely. The previous Swedish survey (Anund et al., 2016) did not find any differences between drivers of different ages, however research on truck and car drivers has shown that drivers who experienced fatigue related incidents were younger than those who did not (Summala & Mikkola, 1994). Gender and socio-economic status (as determined by the multiple deprivation index) were not significant predictors of having to fight sleepiness.

Results relating to factors which predicted having had a sleep related incident in the past 10 years were similar to those predicting having to fight sleepiness, with the exception of the following. Roster type now emerged as a significant predictor, with those on rotating rosters being 40% more likely to have had a sleep related incident than those working fixed rosters. This is unlike the results for having to fight sleepiness in which roster type was not found to be a significant predictor. However, it should be noted that roster type was not a highly significant predictor, and other variables were better able to distinguish between those who had and had not experienced a sleep related incident. A further discussion relating to scheduling can be found in section 4.4.

Late running of buses also now emerged as a strong predictor, with those who experienced late running at least once a month being around 3.5 times (245%) more likely to have had a sleep related incident in the last 10 years. Those who worked longer hours were also more likely to have had an incident than those who worked fewer hours.

Several factors related to work did not emerge as significant in the regressions relating to having had a sleep related incident in the last 10 years, these include: factors relating to breaks during shifts, commuting, and short notice of shifts. This is likely to be because the question relating to sleep related incidents referred to incidents whilst driving the bus or their personal vehicle, therefore incidents may not have occurred whilst working as a bus driver.

Following the initial set of analyses, any factors which were found to be significant predictors were entered together into a further analysis. The purpose of this analysis was to establish which factors were the strongest predictors of either having to fight sleepiness or having a sleep related incident. Five predictors emerged from the model pertaining to having to fight sleepiness, these were; the sleepiness index, the impaired waking index, enjoyment from bus driving, commuting using public

transport, and self-reported sleep quality. With these predictors, this model was able to correctly classify 80% of the cases.

The analysis relating to the outcome of having a sleep related incident in the last 10 years produced a model containing two predictors (the fatigue index and enjoyment from driving) and was able to correctly classify 79% of cases.

3.5.2 Summary

In summary, the survey demonstrated the following:

- Fatigue and sleepiness is a problem for London bus drivers, although fatigue related incidents are under-reported
- Drivers are having to fight to stay awake whilst driving the bus
- Fatigue is caused by a variety of factors related to sleep, work and health. Some of the biggest contributing factors are:
    - Fatigue and sleepiness during the day
    - Shift related issues
    - Insufficient break times/ facilities
    - General driver health

3.6 Task 6: On-road observation

3.6.1 Key findings

Due to practical and technical problems (including the complexity of planning the study, recruiting drivers, and using a specifically equipped bus on a specific route), data from between 12 and 16 drivers are included in the analysis of questionnaires, diaries, sleep pattern and effect on driving behaviour, sleepiness and stress while driving.

3.6.1.1 Background questionnaire

All the participants were full-time bus drivers and had been in the occupation for 11 years on average (range 3 to 17 years). They were on both fixed and rotating rosters. Enjoyment from driving and perceived stress was reported on a scale where 1 is low and 10 is high. The drivers reported high enjoyment from bus driving (mean 7.9, range 4 to 10). Their daily stress level while driving was 3.7 (range 1 to 8) and the general stress level the last three months was 3.3 (range 1 to 10). The drivers reported good health in general (6 very good, 8 quite good, 2 neither good nor bad health). Drivers commute time ranged from 15 minutes to 1 hour 45 minutes, with an average commute time of 50 minutes to and from the depot.

There were no indications of general sleep or fatigue issues among the drivers according to the KSQ (see section 2.5.2). The five sleep indices created from the KSQ (index range from 1-6 and >5 indicates problems) had an average between 1.4 and 2.1 in this group of drivers and none of the drivers had index values above 4. A general question about sleep in the last three months revealed that three drivers had ‘very good’ sleep, eight had ‘quite good sleep’, four had ‘neither good nor bad’ sleep and one had ‘quite bad’ sleep. Eight drivers reported that they never had to fight sleepiness while driving the bus, whereas six drivers reported that it happens occasionally, and two drivers reported 2-4 times a month.

3.6.1.2 Diary results

Results from the sleep and wake diaries were compared between rest days (n=16) and days when the drivers were working morning (n=28) or daytime (n=41) shifts. The drivers reported significantly less sleep before early morning shifts (mean 6h 36 min) compared to rest days (mean 8h 6min) and daytime shifts (mean 8h 1min) (see Figure 3.7). Since the drivers reported their bedtime and wake-

up time, this is a measure of total time in bed and not only time spent asleep. A general question about sleep the previous night, ranging from 1=very bad to 5 =very good, revealed that the drivers slept well most nights; 74% of the nights were rated level 4 or 5, 18% were level 3, and 8% level 1 or 2.

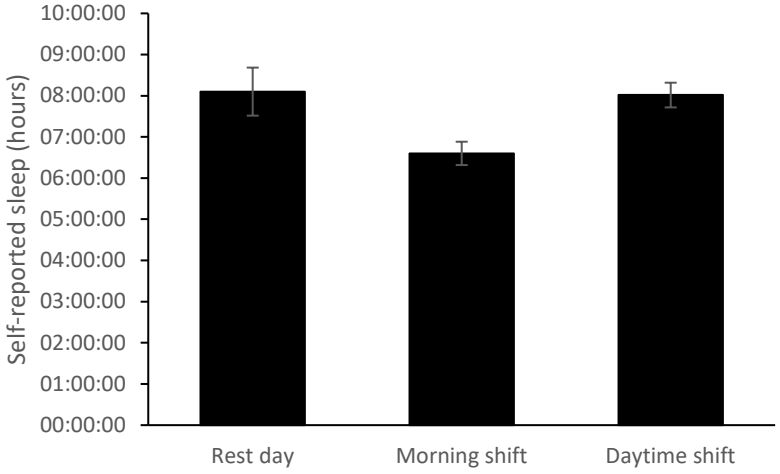


Figure 3.7: Self-reported sleep. Error bars represent standard error of mean (SEM)

In 16% of the work days, drivers reported having to fight to stay awake while driving (5% of morning and 11% of day shifts). In 12% of the days, drivers were feeling so sleepy that it was difficult to be alert or focused enough (1% of morning and 11% of day shifts). In 17% of the days, drivers felt the need to take countermeasures to stay awake (5% of morning and 12% of day shifts). Due to the low number of entries, it was not possible to statistically test differences between morning and daytime shifts.

3.6.1.3 Sleep patterns

The bus drivers slept significantly less, expressed as total sleep time (TST), the night before the morning drive (average TST 4h 51min) compared to the daytime drive (average TST 6h 12min) (see Figure 3.8). This pattern of significantly less TST before the early morning drives remained when TST was averaged over four days before each drive (see Table 3.5). None of the 14 drivers slept the recommended 7 hours (Hirshkowitz et al., 2015) the night before the morning drive. Before the daytime drive, only four out of 15 obtained at least 7 hours sleep. This can be compared to the results from the background questionnaire, where the drivers reported that they needed 7.5 hours of sleep per night to feel rested (range 5 to 12 hours).

Table 3.5: Sleep data derived from actigraphy. Significant results in bold.

	Morning			**Daytime**			
	Mean	Min	Max	Mean	Min	Max	p-value
TST (hh:mm)	4:51	2:08	6:31	6:12	3:56	8:55	**0.009**
SE (%)	77.84	58.99	90.51	80.26	56.46	91.41	0.126
SOL (min)	17	0	77	9	0	57	0.338
4 day mean TST (hh:mm)	5:34	3:52	7:03	6:14	3:07	8:08	**0.037**
4 day mean SE (%)	78.66	56.42	90.02	79.32	44.15	93.71	0.761
4 day mean SOL (min)	11	1	26	14	1	46	0.455

TST=total sleep time, SE=sleep efficiency, SOL=sleep onset latency.

There were no significant differences in Sleep Efficiency (SE) and Sleep onset latency (SOL) between the days before the morning and daytime drives (see Table 3.5). Sleep efficiency below 85% is generally considered poor. Eleven out of 14 drivers had poor SE the night before the morning drive and 10 out of 15 drivers had poor SE the night before the daytime drive.

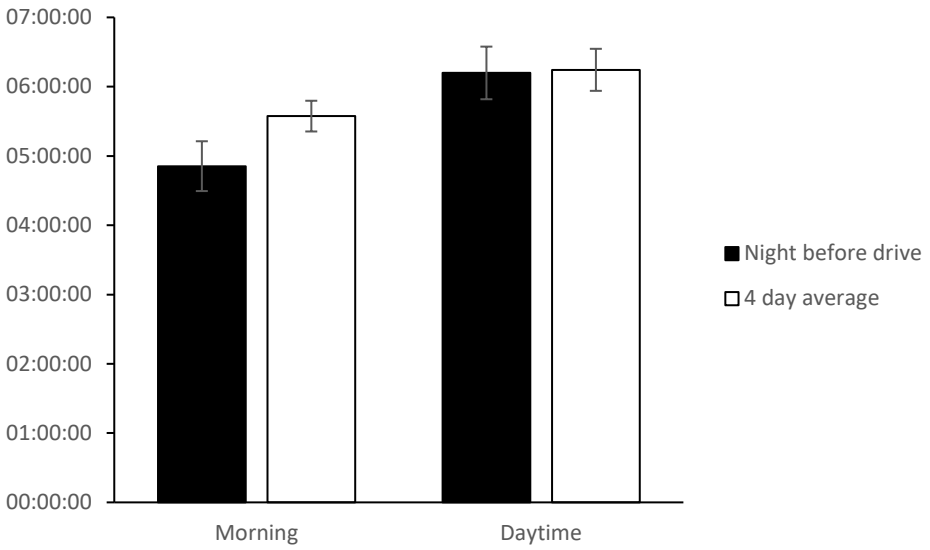


Figure 3.8 Total sleep time. Error bars represent standard error of mean (SEM)

3.6.1.4 Sleepiness, stress and driving behaviour

Comparison was made between the data recorded for morning and day time drives. Sleepiness measured with the Karolinska Sleepiness Scale (KSS) was significantly lower during morning (mean 3.24; SD 1.21) compared to daytime (mean 3.57; SD 1.79) driving (see Figure 3.9). In total 18 KSS reports out of 163 (11%) were higher than 6. Those were reported by five drivers out of 12 (41%) and 15/18 reports were during daytime. A review of KSS sensitivity as an indicator of insufficient sleep and impaired waking function show that KSS levels above 6 in general are related to increased numbers of incidents (Åkerstedt et al., 2014). The KSS results were similar to those achieved in a Swedish experimental study on bus drivers during afternoon driving in a daytime shift showing KSS 3.86 (SD 0.23) and a total of 5/18 drivers (28%) with KSS reports higher than 6 (Anund et al., 2018), but also to an explorative real road study on city bus drivers showing low levels in general, but occasionally high levels of sleepiness occurred (Ahlström et al., 2018). The latter study also highlights the importance of taking the complexity of the driving task into consideration for sleepiness detection, something that is also emphasized in other studies where results indicate that action demand is important to understand sleepiness in drivers (Ahlstrom et al., 2017). Results from GLM ANOVAs can be seen in Appendix K.

The average self-reported stress level measured with the Stockholm Stress Scale (SUS) was 3.02 (SD 0.68) during morning and 2.95 (SD 1.50) during daytime (see Figure 3.9). In total 3 SUS reports out of 163 (2%) were above 6, and those were reported by two drivers and only during the daytime drive. During daytime, there was more traffic, congestion and interaction with other road users, issues that might be expected to contribute to a higher workload.

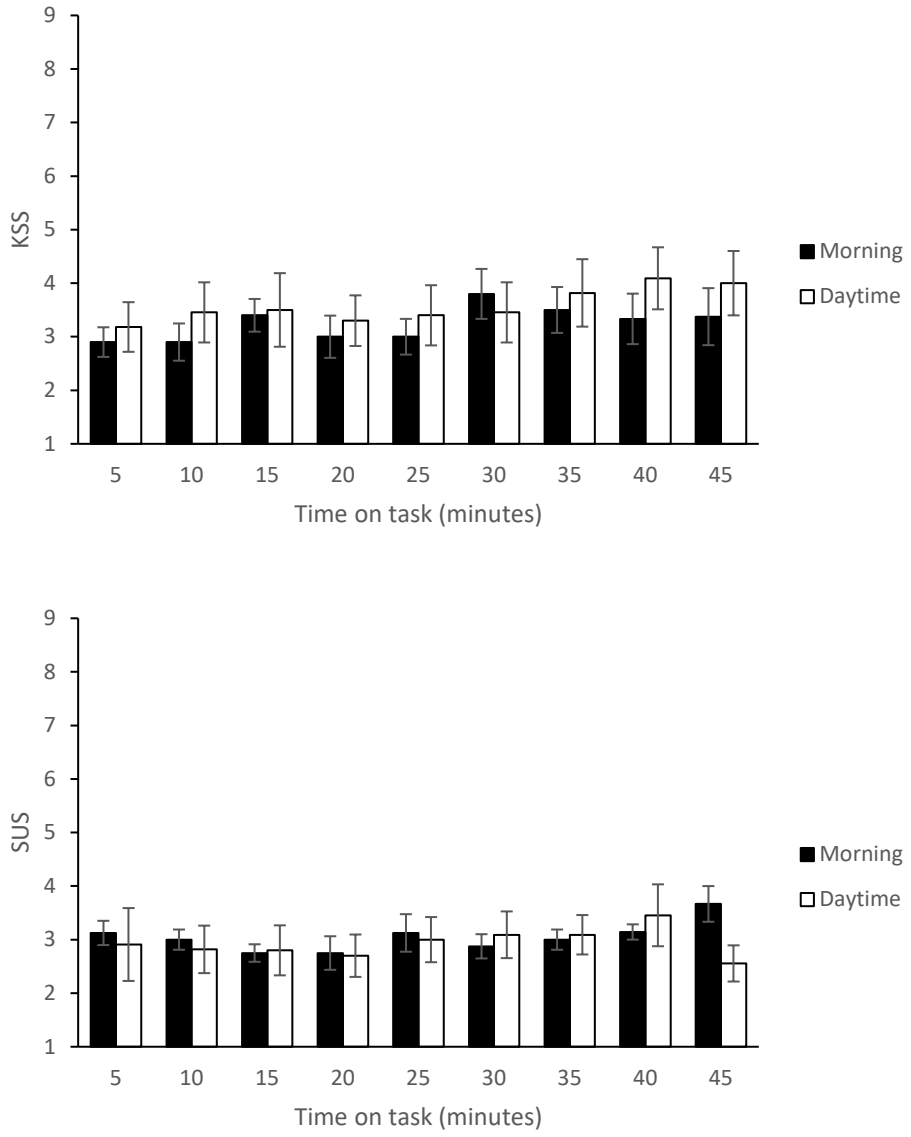


Figure 3.9 KSS and SUS morning and daytime. Error bars represent standard error of mean (SEM)

One commonly used indicator of fatigue is long blink durations. The average blink duration was significantly longer during morning drives (mean 0.134 seconds; SD 0.027) compared to daytime drives (mean 0.124 seconds; SD 0.0321) (see Figure 3.10). The same pattern was seen for the percentage of long blink durations (>0.15 seconds), with significantly higher percentages of long blinks during mornings compared to during daytime drives (see Figure 3.10). Most studies looking into the effect of long blinks on safe driving are done on rural roads and do not involve handling complex environments such as urban driving. On rural roads it has been shown that blink durations >0.15 seconds are associated with an increased risk for the vehicle crossing the lane demarcation line (Fors et al., 2011). It has also been indicated that long blink durations have a different effect on line crossings depending on whether they are prevalent during daytime or night time (expected sleep deprivation condition) (Anund et al., 2017).

Worth mentioning is that from the video analysis, one driver had problems keeping his eyes open and showed signs of falling asleep at red lights, in queues and at bus stops. The driver's report of KSS did not correspond to the view from the video, indicating a possible risk of drivers underestimating sleepiness or not understanding how to use the scale. It is not known why, but studies on bus drivers

have shown that they seem to use the self-reports in a different way compared to other populations that have been studied mostly in situations with more task-related underload. One explanation might be that the bus drivers were fully occupied with the driving task in the complex environment, which might make it difficult to give self-reports due to overload. They could also be less familiar with how self-rating scales work.

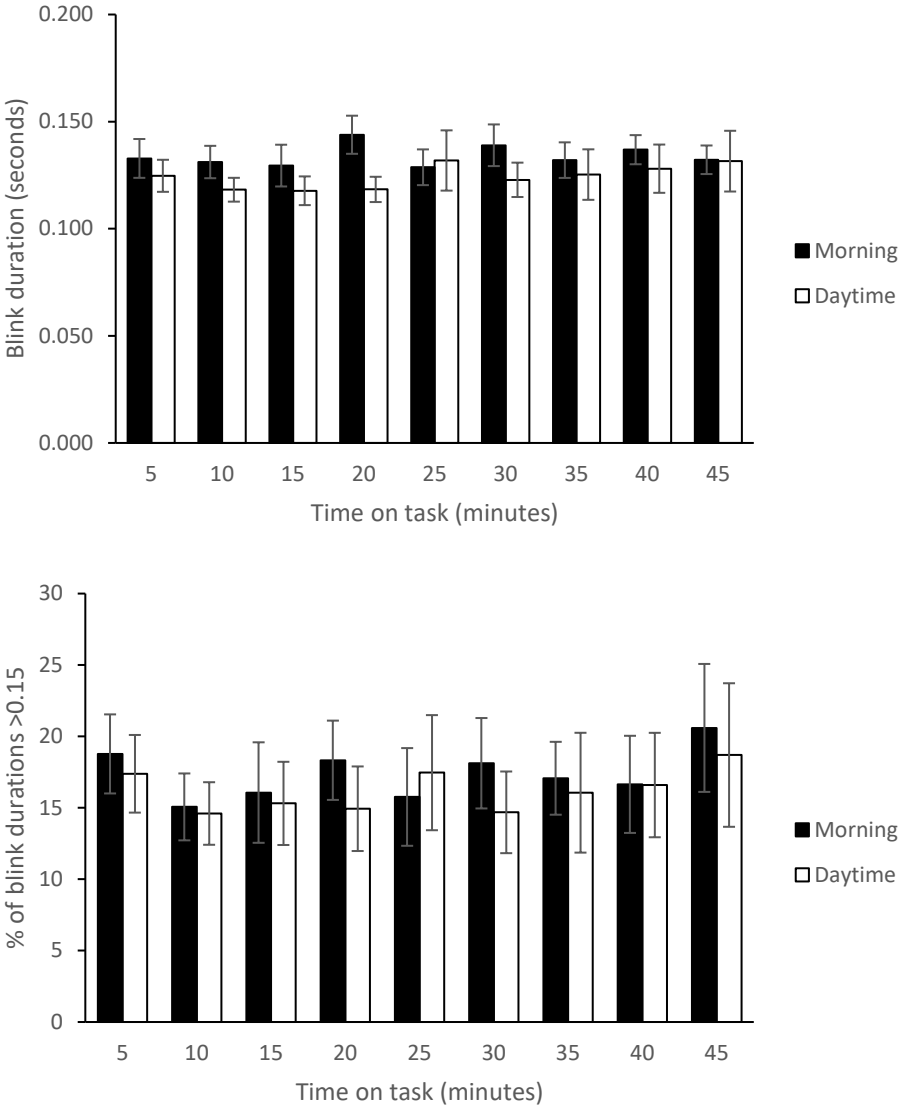


Figure 3.10 Mean blink duration and percentages of blink durations longer than 0.15 seconds. Error bars represent SEM.

There was a significant difference between heart rate variability (HRV) during mornings (mean 0.03831; SD 0.0179) compared to daytime driving (mean 0.03221; SD 0.130) indicating higher psychological stress during daytime than during morning (see Figure 3.11).

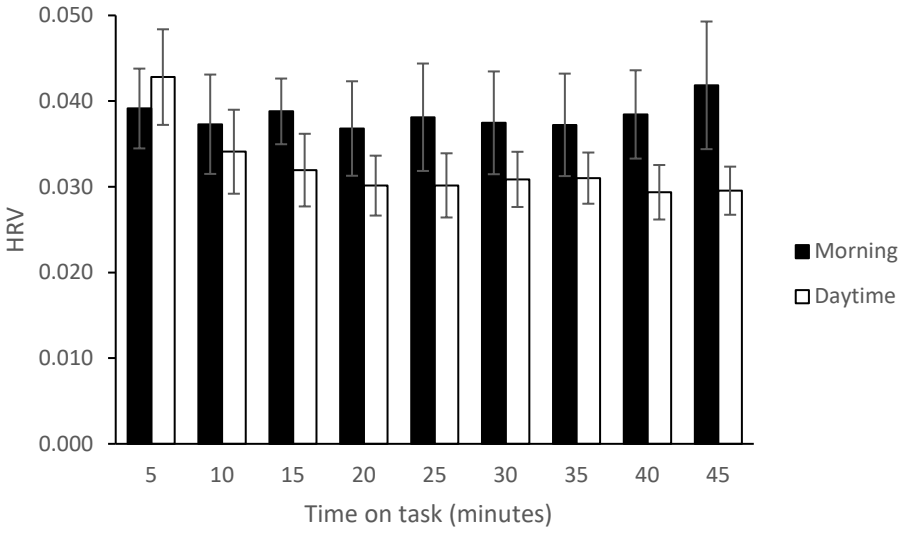
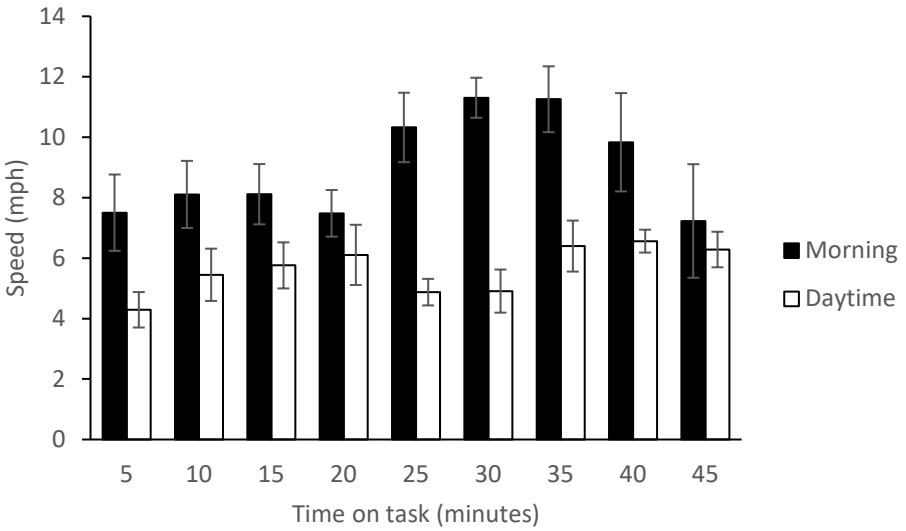


Figure 3.11 HRV RMSSD. Error bars represent standard error of mean (SEM)

Driving behaviour during morning and daytime differed significantly (see Figure 3.12). The average speed was higher during morning (mean 9.00 mph; SD 3.55) than daytime (mean 5.64 mph; SD 2.38). The same pattern was seen for accelerations and decelerations. It is not possible to determine whether these findings are caused by the effect of time of the day itself or the change in driving conditions because of time of day i.e. daytime driving being more demanding with more traffic, pedestrians and cyclists. Most likely it is dependent on the complexity of the driving task and the demand for action due to high traffic density (Ahlstrom et al., 2017). Whether or not the levels of accelerations/ decelerations will lead to risky situations is hard to say, but it would likely not be comfortable for the passengers and with higher accelerations/ decelerations there is a risk for standing passengers to fall. The impact of accelerations on whether or not passengers fall on the bus, is highly dependent on various other factors such as whether or not the passenger is standing, their position, whether a handrail is present, and whether or not they are on the stairs. However, research has shown that it is more common for passengers to experience a fall when acceleration is greater than 2.5 m/s^2 (Karekla & Tyler, 2019).



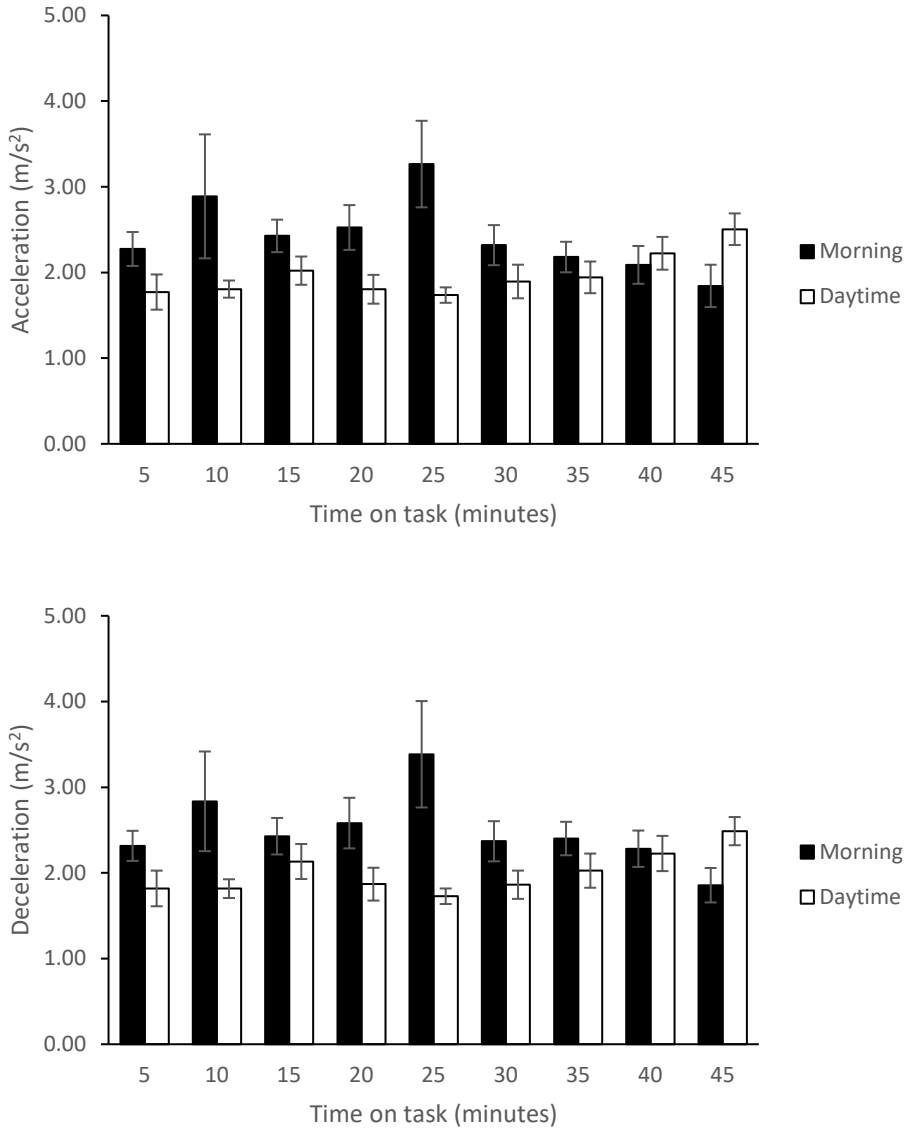


Figure 3.12 Speed, Accelerations and Decelerations. Error bars represent standard error of mean (SEM)

3.6.1.5 After drive questionnaire

It can be generally noted that many drivers indicated values in the low extreme throughout the questionnaire, i.e., stating that they experienced no stress at all. No significant difference between morning and daytime was found on any of the three variables; difficulties in staying awake, feelings of stress, and worry while driving ($p>0.05$). Thus, according to the responses in the questionnaire, the time of the day they work did not seem to influence experiences in the area of (a) difficulties in staying awake, (b) stress while driving, or (c) worry (see Figure 3.13). Although self-reported sleepiness and stress were higher during the daytime drive, these responses can not be directly compared to those in the after drive questionnaire. First, two different scales were used to assess both sleepiness and stress whilst driving and after driving. Second, the after drive questionnaire required drivers to respond retrospectively whilst the scales used during the drive involved real time reporting. Therefore, greater weight should be placed on self-reported sleepiness and stress ratings during the actual drive.

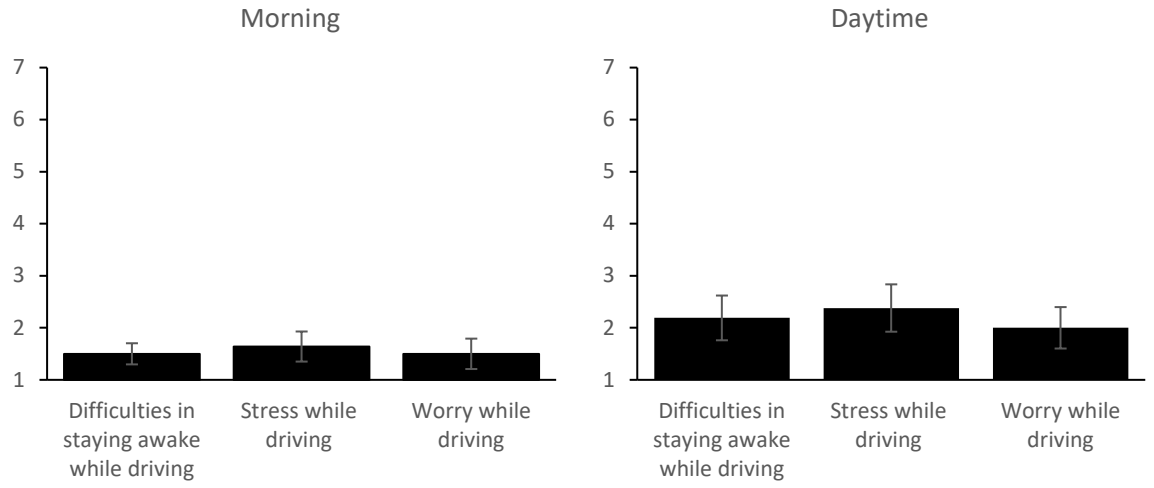
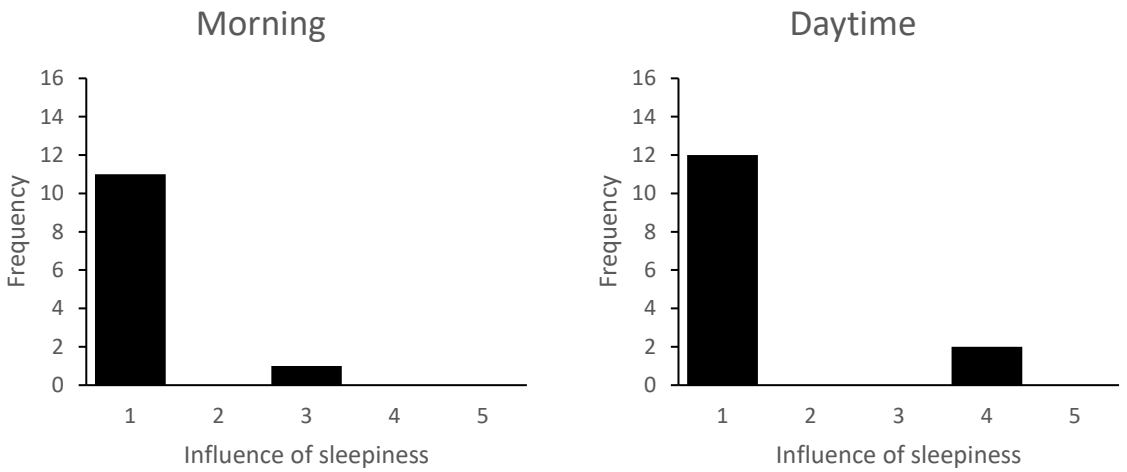


Figure 3.13 Drivers experience of sleepiness, stress and worry while driving.

The drivers considered the experimental drives in general to be fairly similar to an ordinary drive on the same route, with no major difference between morning (mean 5.6; SD 1.7) and daytime driving (mean 5.3; SD 1.9).

The drivers tended to report that sleepiness, inattentiveness or stress had no influence on their driving (see Figure 3.14). There was no significant difference between morning and daytime reporting ($p>0.05$). One driver reported losing attention during the day drive and eight drivers, five in the morning (36 %) and three in the day (19 %), reported experiencing sleepiness at some time of the drive. Four drivers, one in the morning and three in the day, reported using a countermeasure to stay awake. From the free text answers, it could be seen that these incorporated drinking energy drinks, chewing gum and singing. None of the drivers indicated that control of the vehicle was lost during the drive. In all, this is in line with what previous research has shown (Anund et al., 2008).



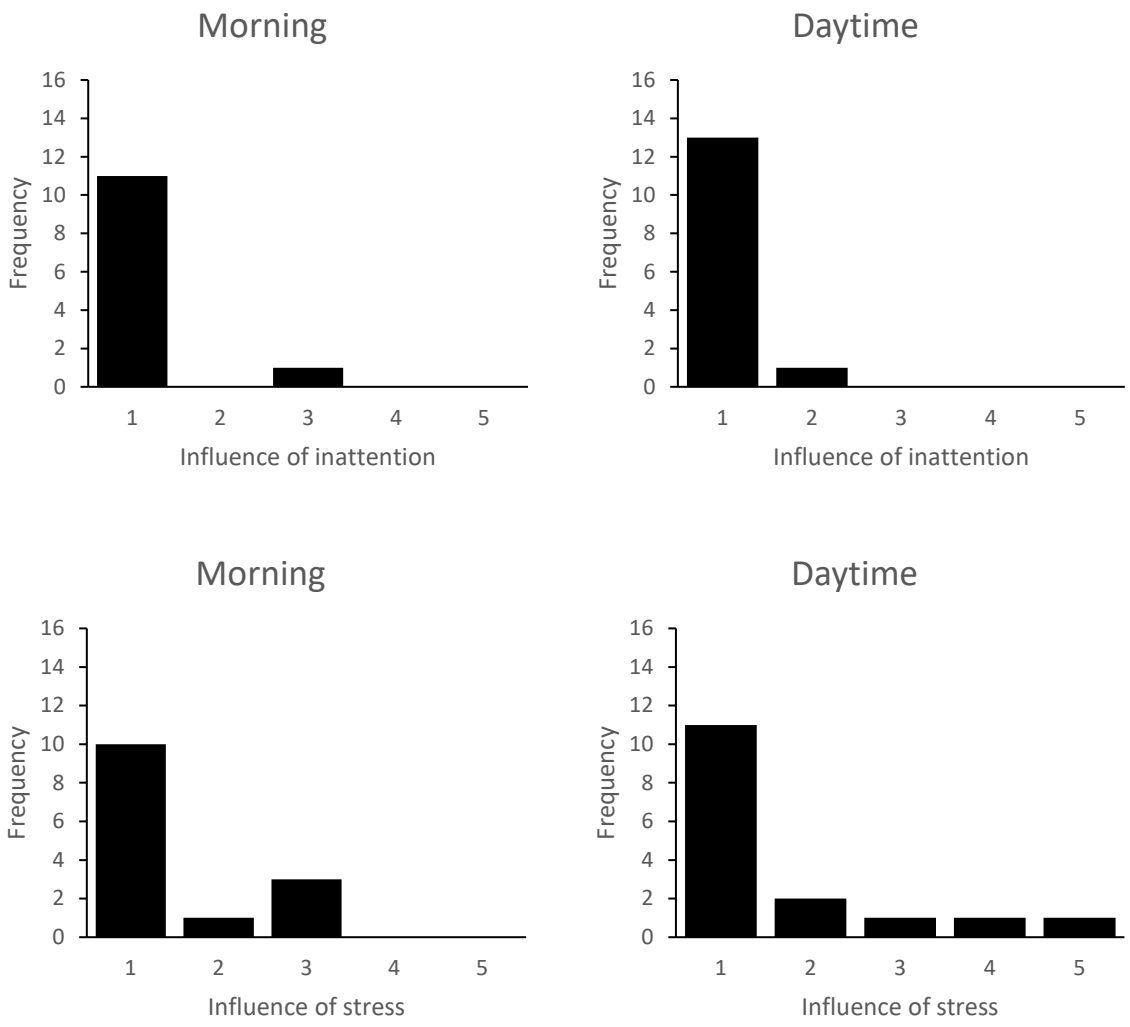


Figure 3.14 The influence from sleepiness (top), inattention (middle) and stress (bottom) while driving

Responses to the free text questions suggest that the reasons for experiencing stress, fatigue and inattentiveness were short sleep, (difficult) interactions with traffic, passengers and traffic controllers, time pressures, family matters and illness.

3.6.2 Summary

To summarise:

- Drivers sleep too little especially before morning shifts (1.5h less than recommended)
- In general, self-reporting of sleepiness is not very high, but individuals report high levels now and then.
- The drivers report higher sleepiness during daytime than during morning drives.
- However, objective measures like blink durations show more sleepiness signs during mornings.
- There is a need to be aware of fatigue as a potential risk not only at times of the day when you would like to be in bed, but also at times of the day when the task itself is demanding.

4 Discussion of potential solutions

The following section discusses the proposed solutions derived from the research that could potentially mitigate fatigue in London bus drivers. It is important to recognise that the responsibility to manage fatigue is shared. The solutions discussed are relevant for all involved parties (drivers, managers, operators at all levels, TfL, borough councils, unions, and the Department for Transport [DfT]). In order for any solution to be effective each party must take ownership of the issue and where possible provide support to facilitate all other parties in fatigue management efforts.

As part of this programme of research, operators were asked for policy documents that related to fatigue, which have been summarised in section 3.2, the internal policy review. However, it is possible that some fatigue policies were not volunteered at the time, or that policies and initiatives relating to fatigue have been implemented and adopted since the request was made. Therefore, there may be some instances where aspects of the themes and solutions are already being undertaken, for example trialling fatigue detection technology, utilising biomathematical models of fatigue in relation to scheduling, or providing adequate facilities for drivers to eat and rest. It is also important to focus on establishing a standard in terms of fatigue mitigation, that can be applied across operators and TfL.

Within this section, solutions and countermeasures are discussed which can be targeted across two levels, individual and organisational. Individual countermeasures refer to the strategies and solutions that individuals themselves can adopt and use to alleviate fatigue and sleepiness, including preventative strategies to help mitigate fatigue before it occurs, and operational strategies aimed at mitigating the effects of fatigue which may be present. Solutions can also be targeted at an organisational level, for example implementing a fatigue management system, educational programmes, or providing rest facilities. It should be noted that the proposed solutions and countermeasures to driver fatigue have not been evaluated (meaning that they have not been subject to a randomised control trial, or a comparison before and after the implementation of a certain solution). They have been proposed and their potential rated based on findings from the literature review and the research conducted as part of this body of work. It is also important to note that the scientific literature considered is limited in that no objective, high quality evaluation of solutions and countermeasures to fatigue and sleepiness in drivers, especially bus drivers, were identified. Therefore, it is recommended that if any solutions are implemented, an evaluation into the effectiveness of the countermeasure should be conducted.

Each research task (literature review, policy review, focus groups, manager interviews, online survey, and on-road study) resulted in several findings which were then consolidated, and potential fatigue countermeasures or solutions were generated (a summary of the tasks which influenced each solution can be found in Appendix L). The proposed solutions were then reviewed by the research team as part of a two-day workshop discussion, considering the strengths and weaknesses of each, and discounting those solutions with little or no potential to reduce driver fatigue. Five themes emerged from the discussions: education, working conditions, schedules, open culture, and health, with the recommended solutions fitting within these themes. These themes and respective solutions were then allocated ratings according to the potential for reducing driver fatigue, anticipated time to introduce the solution, indication of cost and the effort required to achieve the full potential to reduce driver fatigue. The ratings are provided as a guide only, as in reality, additional factors could influence the outcomes, with cost, potential for reducing fatigue, and time to introduce being dependent on the manner in which the solutions are implemented. Within each theme, there is also information detailing, where possible, the use of similar countermeasures in other, relevant, occupational and transport settings. The idea of a multi-level approach to address and manage

fatigue in occupational settings is becoming increasingly popular, with a recent consensus statement from the Working Time Society providing broad guidance on managing sleep-related fatigue associated with non-standard working hours (Wong, Popkin & Folkard, 2019). Within the current report countermeasures were discussed in section 3.1.1.3, in the current chapter examples from literature are provided where possible in discussing potential solutions. However, a systematic literature review of countermeasures to sleepiness and fatigue has not been conducted, rather the primary focus is on literature related to bus drivers and the proposed solutions.

It is important to bear in mind that the proposed solutions described below are fatigue and sleepiness focused. There may be broader operational issues that would need to be taken into account when considering if, or how, to implement these solutions.

4.1 Solutions overview

The summary table below (Table 4.1) identifies the five overall themes which emerged from the consolidation of findings and compares the ratings of the various outcome measures in relation to each other. Following this, each theme is discussed in more detail, with the proposed solutions ordered in terms of the numbers of research tasks the solution arose from.

The ratings provided should be used a guide only - knowledge of fatigue and the evaluation of fatigue countermeasures, especially in relation to bus drivers, is limited resulting in difficulties for applying ratings for each of the themes. The ratings were informed by the literature review, the research conducted, and the expertise of the researchers. As the field of fatigue and countermeasures is underdeveloped, particularly in relation to bus drivers, no objective, high quality evaluation of potential solutions and countermeasures has been conducted. Therefore, none of the proposed themes have been awarded the top rating for the potential for reducing driver fatigue. Solutions which are thought to have no potential for reducing driver fatigue have been excluded from the proposed solutions. In terms of anticipated cost, this is only an indication, as the actual costs of implementing proposed solutions have not been researched or evaluated. Cost and time may also vary depending on the approach taken or the solutions that are addressed within themes, which could be exponentially higher depending on which aspects are implemented. Introducing any mitigation or solution to fatigue will be influenced by, and require the engagement of all parties, and should be viewed as a shared responsibility by all.

Table 4.1: The 5 overall themes which emerged from the consolidation of findings, including ratings of various measures relevant to each other

	Potential for reducing driver fatigue	Anticipated time to introduce	Cost indicator	Effort required to achieve the full potential to reduce driver fatigue
Education	*	Short term	£	•••
Working conditions	***	Medium term	£££	••
Schedules and rosters	***	Short term	£££	••
Open culture	****	Long term	£-£££	•••
Health (including sleep health)	**	Medium term	££	••

All values relative indications only.

Potential for reducing driver fatigue:

********* Demonstrated to be effective by several high-quality evaluations with consistent results.
******** Demonstrated to be effective in certain situations.
*** Likely to be effective based on evidence and sources reviewed.
** Effectiveness undetermined, different methods of implementation may produce different results**.**
* Limited and restricted potential for reducing fatigue.

Anticipated time to introduce:

Long term More than one year.
Medium term More than six months but less than one year.
Short term Six months or less.
These estimates do not include the time required to enact legislation or establish policies.

Cost Indicator:

£££ Requires extensive new facilities, employees, equipment, time, or publicity, or makes heavy demands on current resources.
££ Requires some additional employee time, equipment, facilities, and/or publicity.
£ Can be implemented with current employees, possibly with training; limited equipment costs, facilities, and publicity.
These estimates do not include the cost of enacting legislation or establishing policies.

Effort required to achieve the full potential to reduce driver fatigue:

••• Requires maximum effort, with all parties involved and engaged, to achieve the full potential of reducing driver fatigue.
•• Requires some effort to achieve the full potential of reducing driver fatigue.
• Requires minimal effort to achieve the full potential of reducing driver fatigue.

Although the following sections have been separated into the five themes, with the respective solutions listed below, it should be noted that a holistic approach, which encompasses or addresses aspects of each of the themes, would potentially prove to be the most beneficial in terms of reducing driver fatigue.

Within each theme the solutions have been ordered according to the number of times they emerged from a task.

4.2 Education

	Potential for reducing driver fatigue	**Anticipated time to introduce**	**Cost indicator**	**Effort required to achieve the full potential to reduce driver fatigue**
Education	*	Short term	£	•••

4.2.1 Overview

Research indicates that educating people on aspects of sleep, shift work, and effective measures to counteract sleepiness, can be a useful and important prevention strategy. In terms of bus drivers, literature has indicated the need for education interventions in terms of sleep hygiene (Deza-Becerra et al., 2017), the importance of sleep in relation to driving (Razmpa et al., 2011) and countermeasure use, in particular during split shift working (Anund et al., 2018). It is important that other parties are also involved in education and training, such as managers and shift schedules, to ensure that the knowledge level regarding fatigue and sleepiness is similar throughout the operation. Research has shown mixed results in terms of the effectiveness of training in reducing fatigue and sleepiness amongst drivers, however changing behaviour and attitudes can take time, and it may be that in previous studies, the training has been too simplistic, or one-off training has been delivered, with limited effects.

4.2.2 Proposed solutions

- **Education relating to sleep and lifestyle**
  Education relating to sleep and lifestyle for all drivers, in particular new drivers who may not have experienced shift work before. This should include promotion and education relating to management of rest, emphasising **driver responsibility to prioritise sleep and ensure they are well rested prior to duty**. For instance, TfL have recently funded a new one-day Certificate of Professional Competence (CPC) training course, 'Destination Zero', which will be delivered to all 25,000 bus drivers over the next 18 months, which includes a focus area of fatigue and wellbeing management. However, education packages should also be extended beyond drivers and delivered to the majority of people within operators such as managers and shift schedulers, to provide an overall understanding of sleep, shift work, and effective countermeasures to sleepiness. The importance of including education as a fatigue mitigation strategy lies in the increasing of awareness of fatigue in the workplace, which will likely aid in the success of further implementations (Williamson & Friswell, 2008). Research has shown that short, one off training programmes have limited effectiveness. Following a mandatory 60 to 90 minute training session providing information and advice relating to sleep and countermeasure use, shift workers still consistently obtained less than adequate sleep (Arora, Georgitis, Woodruff, Humphrey & Meltzer, 2007). Therefore, longer programmes, for example a set number of sessions, may be more effective (Chen, Kuo &

Chueh, 2010). However, it has been reported that education as a sole fatigue countermeasure is ineffective at changing sleep behaviours (Pylkkönen et al., 2018) and therefore will most likely have limited impact if implemented in isolation.

4.2.3 Potential for reducing driver fatigue

Driving research has indicated that education strategies work well for individuals who are not already aware of the risks of fatigue (Gander et al., 2005). However, education can have a limited impact on those who understand the risks of fatigue, but continue due to other factors (Armstrong et al., 2010; McCartt et al., 2000; Nordbakke & Sagberg, 2007), with financial and business demands creating additional pressure for professional drivers (Firestone & Gander, 2010). Education packages need to be realistic and relevant, and require individuals to engage with the content, focusing on recognising the symptoms of fatigue, the causes, consequences, and countermeasures, and have the motivation to act on the knowledge that they have learnt. Of particular importance in a workplace context is that individuals need to be provided with the opportunity to implement learnt strategies, whether that be adequate rest periods between duties to ensure sufficient sleep, suitable facilities and the open culture to allow drivers to nap during breaks, or the system in place to be able to report fatigue. It is also important that training and education is conducted with fully alert participants, who are responsive and willing to engage. If training is conducted following a normal working shift, or on sleepy individuals, the learning is likely to be limited. Therefore, it is important to consider the time the training and education is delivered. The complexities of these factors are highlighted below in Figure 4.1. Although education can offer some benefit, the potential for reducing fatigue is limited.

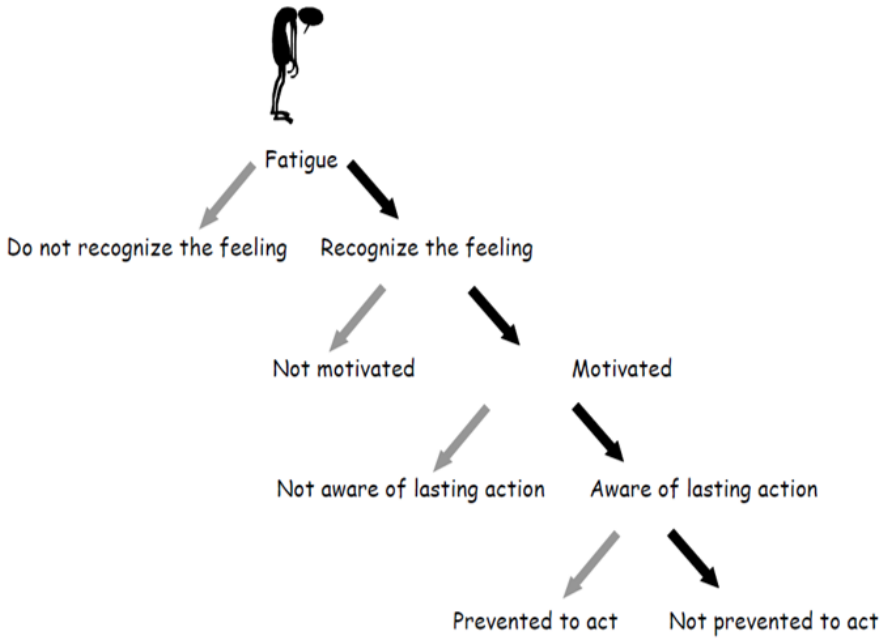


Figure 4.1: The chain of decisions relating to countermeasure use and driver fatigue (Anund, Fors, Kecklund, Leeuwen & Åkerstedt, 2015).

It is important to note that while there has been evidence to suggest that education as a sole intervention to reduce fatigue and sleepiness can be ineffective, education and training are the cornerstones of other interventions, with most other potential solutions requiring an element of training and education.

4.2.4 Anticipated time to introduce

The anticipated time to introduce would be short, as this would be an addition to the education already provided by operators, focusing only a part of their training programme on fatigue. However, this would depend on the time to develop the additional material and inform/train the current facilitators. A further consideration is the time taken to deliver the training course to the driver population, which may take considerable time, and may involve additional costs, such as covering shifts during training, which needs to be taken into account.

4.2.5 Indication of cost

The potential cost of implementing an education package relating to fatigue should be relatively low, as operators currently provide training and education to their drivers on a regular basis. Therefore, the proposed fatigue education could be incorporated into the current training package, requiring little additional cost. However, if education cannot be incorporated into current packages, then the associated cost will be higher. For example, operators currently use the CPC format of a one-day training course per annum, which includes varying content. Therefore, introducing a 'fatigue package' alongside or in addition to this may incur significant costs. Training and education solutions could incorporate operators providing in house training, or a standardised approach across all TfL routes. The quality, content and consistency of the material across TfL and operators will influence the variability of results.

4.2.6 Effort required to achieve the full potential to reduce driver fatigue

As mentioned above, while offering some benefit, especially to new drivers, education as a sole fatigue countermeasure can face several challenges. Although the time to implement is possibly short, and the indications of cost may be low, thought needs to be put into the content of the education package, and how it will be delivered to make sure that it is engaging, relevant, and realistic, all of which requires effort. However, to potentially reduce driver fatigue, individual motivation as well as responsibility for managing rest and health in terms of fitness for work is required, and therefore results may be difficult to achieve.

4.3 Working conditions

	Potential for reducing driver fatigue	**Anticipated time to introduce**	**Cost indicator**	**Effort required to achieve the full potential to reduce driver fatigue**
Working conditions	***	Medium term	£££	••

4.3.1 Overview

Working conditions are an important consideration in terms of bus driver fatigue and are often out of control of the drivers themselves. Physical and psychosocial factors have been shown to contribute to health, stress and fatigue experienced by bus drivers (Tse et al., 2006), with factors such as vehicle condition and ergonomics, shift work, and the risks of violence just some of the stressors experienced by drivers. Literature has indicated associations between cabin ergonomics and fatigue (Biggs et al., 2009), and overall bus condition and accident rate (Abdullah & Von, 2011). Heat, noise, and vibration have also been shown to impact fatigue and increase stress levels of drivers (Abdullah & Von, 2011; Biggs et al., 2009) highlighting the importance of bus condition and design. Access to adequate facilities was also highlighted in the literature, with reports of bus drivers

sleeping in inappropriate places during their break due to lack of facilities, resulting in instances of poor sleep quality (Deza-Becerra et al., 2017). Concerns relating to a lack of facilities were also identified in the driver survey and focus groups. Providing facilities which enable drivers to be able to nap and rest (including access to adequate bathroom facilities), or to socialise and eat healthily, as well as maintaining buses to a suitable working standard, could potentially address some of these challenges and offer solutions in terms of potentially reducing driver fatigue.

4.3.2 Proposed solutions

- **Provide and ensure regular evaluation of suitable facilities for drivers to eat and rest**
  Literature has indicated that access to adequate driver facilities relating to rest/napping and food/eating, is an important aspect of fatigue management, with research from the various tasks supporting the need for adequate facilities (including suitable bathroom access). By providing access to appropriate rest areas, drivers would have the opportunity to nap or rest prior to duty, during breaks, or prior to commuting home, which could potentially counteract fatigue during shifts. Research in groups of shift workers has shown the beneficial effects of napping during shifts in relation to fatigue mitigation, including engineers (Purnell, Feyer & Herbison, 2002), pilots (Rosekind et al., 1995), and air traffic controllers (Signal, Gander, Anderson & Brash, 2009). Although not as recuperative for sleepiness as napping, rest breaks do provide a respite from the job and tasks, mitigating against task related fatigue and improving safety (Tucker, 2003; Tucker, Folkard & Macdonald, 2003). Access to food and healthy eating is also difficult due to timings of shifts and locations drivers find themselves in, limiting availability and food choice, particularly at certain times of the day, however providing adequate eating facilities offers potential for reducing driver fatigue and improving overall driver health. Solutions relating to drivers' diet would be linked to education and promotion regarding the benefits of healthy eating, and **improved access to facilities to enable healthy eating**. A review of literature relating to food and shift work by Lowden, Moreno, Holmbäck, Lennernäs and Tucker (2010) led to several guidelines relating to eating whilst working shifts. A key theme in these guidelines was having a variety of food options available and avoiding low-quality foods such as those high in carbohydrates or high in sugar. It is important that a regular systematic assessment is made of the facilities, to ensure that the changes implemented remain valid, and to address any risks or further interventions that need to be addressed.
- **Maintain buses to ensure they are always kept in a suitable condition**
  Previous literature and responses during focus groups have highlighted the importance of ensuring that buses are kept in suitable working conditions and to a high technical standard, to help reduce stress experienced by drivers (Abdullah & Von, 2011; Biggs et al., 2009). Drivers need to trust the bus will operate throughout their duty, with increases in stress reported if problems and issues arise with the buses. For example, it has been recognised by TfL that there have been certain technical and software issues with the new hybrid buses, and although there is no evidence that these are safety critical issues, they can cause stress and anxiety for the drivers.

4.3.3 Potential for reducing driver fatigue

Implementing solutions related to working conditions are likely to be effective at reducing driver fatigue. Often the establishment of, or access to, facilities, as well as bus maintenance, are out of the control of the driver, which potentially could impact stress levels. It is considered that providing adequate rest facilities will assist drivers with the opportunity to nap or rest. Similarly, by providing adequate food and eating areas, drivers will have the opportunity to eat healthily. It should be noted

that an audit of current facilities was not conducted as part of this research. However, in terms of facilities, individual motivation and engagement will impact the potential for reducing fatigue, so it is therefore important to educate the drivers about using the facilities, publicise the availability of any facilities, and establish an open culture to encourage napping and healthy eating. It is also important that a regular evaluation of the facilities is conducted in order to address any additional needs. Ensuring buses are maintained to an adequate standard could reduce the stress experienced by the drivers relating to the working condition of the bus, which has the potential to reduce fatigue.

4.3.4 Anticipated time to introduce

The anticipated time to introduce and implement will likely vary depending on the current facilities and condition of buses, and how these will be improved and utilised in the future. It is likely to involve a medium time scale, however, certain aspects may require considerable re-engineering of work practices and facilities to make any meaningful impact. There is also the issue of planning and set up time prior to implementation, and other features such as maintenance necessitating an ongoing strategy.

4.3.5 Indication of cost

The potential cost of implementing solutions relating to working conditions is quite high. Costs would vary depending on whether improvements to existing facilities could be made, or if new facilities for rest/napping and access to food would be needed, with additional costs relating to ongoing maintenance of buses to ensure adequate working condition.

4.3.6 Effort required to achieve the full potential to reduce driver fatigue

The effort required to achieve the full potential to reduce driver fatigue will be influenced by how the proposed solutions are addressed. Existing facilities can be improved, or new facilities created, for both rest and eating, however effort may be required to ensure that these are used appropriately, and driver input would be an important factor in terms of requirements. Although there is a shared responsibility in terms of solutions to reduce driver fatigue, there is an expectation that drivers take responsibility and manage their overall health and fitness for work, especially if the education and facilities are provided. Regular evaluation of the validity of implemented changes should also be conducted, identifying any further risks or needs. If drivers are not educated in the benefits of napping or eating healthily, and there is no engagement or motivation from the drivers or other parties, all of which requires effort, then the potential for reducing driver fatigue may be limited. For example, if drivers feel that they will be judged or penalised by their employer for using nap or rest facilities then uptake is likely to be low.

4.4 Schedules and rosters

	Potential for reducing driver fatigue	**Anticipated time to introduce**	**Cost indicator**	**Effort required to achieve the full potential to reduce driver fatigue**
Schedules and rosters	***	Short term	£££	••

4.4.1 Overview

Shift patterns and rosters directly impact drivers and their ability to rest, sleep, and achieve a good work/life balance. Literature has shown that increased sleepiness and crash risk are impacted by

long working hours (Robb et al., 2008), especially when combined with sleep loss and lack of breaks (Pylkkönen et al., 2015). Schedules should be reflective of the 'real world', for example in relation to traffic levels, with research highlighting the main contributing factor to bus driver fatigue to be unrealistic scheduling (Biggs et al., 2006). In terms of implementation, education may be required for schedule planners in order to incorporate fatigue mitigation strategies into the schedules and rosters, such as the solutions listed below. Implementing strategies that consider working patterns, rest and break times, length of duty, variability and flexibility of shifts, consecutive long or early shifts and cumulative fatigue risk is important, ensuring drivers have the opportunity to adequately manage their work and home life.

4.4.2 Proposed solutions

- **Including fatigue risk assessment and mitigation in scheduling and rostering**
  Several potential solutions relating to fatigue risk assessment and mitigation in rostering and scheduling arose from the literature, expertise, and the research conducted, and have therefore been grouped together. **Safety and fatigue should be a main consideration** when designing schedules and shift patterns, whether that be through modelling rosters through specialist software (e.g. the Health and Safety Executive [HSE] Fatigue Risk Index), limiting the number of consecutive early shifts, the number of continuous hours worked, or establishing tighter control regarding shift swapping and overtime. Understandably, scheduling and rostering for bus drivers can be complicated due to the complexity of operations, and varying staffing needs, not only daily, but sometimes hourly. This fine detail results in start times for current shift patterns varying daily. However, drivers are unlikely to adjust their bed time in such fine detail which will result in daily difference in sleep duration. **Reducing the variability in start times** within specific shifts, for example, for having all early morning shifts starting within the same small consistent time window. This will aid drivers in the planning and management of rest and sleep prior to and following duty.

  Literature has shown that in terms of shift work rotations, **forward rotating shift patterns**, which involves duty start times getting progressively later such as moving from earlies, to middles then to lates, coincide with our circadian rhythms, and are therefore easier to sleep around. It also prevents short rest periods between duties, as forward shift rotation makes it impossible to have less than 11 hours rest between shifts. In terms of rest between shifts, research has recommended that to promote optimal health in adults between the ages of 18-60, 7 hours of sleep or more per night should be obtained on a regular basis (Watson et al., 2015). Therefore, **allowing at least 11 hours rest** would ensure time for drivers to commute to and from work, rest and prepare for duty, as well as allowing opportunity for family/social time. Ensuring that shift patterns follow this rule will aid drivers in managing their rest prior to duty. Research has also shown the importance of regular and adequate breaks during duties, to enable drivers to rest, eat, and use facilities. It was noted from the survey data that drivers experience insufficient time to eat and rest, and therefore **increasing the number of breaks per duty**, especially with long duty days, may improve this and potentially reduce fatigue and stress levels. Regular rest breaks have been recommended in order to prevent the accumulation of accident risk, (Tucker et al., 2003), particularly in sustained activities such as driving. Research has shown that during an 11-hour shift, taking breaks reduced the odds of a crash by 68%, 83% and 85% for one, two or three rest breaks respectively, compared to drivers who did not take a rest break (Chen & Xie, 2014).

From the research conducted, there was a concern regarding reduced sleep prior to early morning shifts, which could potentially affect alertness, performance and safety. Sleepiness may then accumulate over the consecutive early shifts, increasing fatigue risk, as individuals may struggle to obtain adequate sleep prior to duty. Previous research has shown links between starting work too early in the morning, and short sleep duration and increased sleepiness (Ingre, Kecklund, Åkerstedt & Kecklund, 2004) partly due to the inability to go to sleep earlier to compensate. Therefore, limiting rosters to **avoid more than three consecutive early morning shifts** would mitigate this risk and potentially reduce fatigue experienced by bus drivers. However, it is understood that introducing rules such as this may not always be feasible from a business point of view. One policy which has been adopted by some operators is to use shorter shift lengths for early shifts in an effort to mitigate the associated fatigue effects with consecutive early starts. Due to the findings in the literature review, it was expected that spread-over shifts would emerge as a major issue for bus driver fatigue, however, from the research conducted, split shift working does not often occur in London, which is positive. Moving forward, this approach should be continued, **avoiding the use of spread-overs** to help mitigate fatigue risk.

There are currently **biomathematical models** which have been established to predict the impact of shift schedules on respective sleep, alertness, and performance (e.g. the HSE Fatigue Risk Index). This or other similar tools could be useful when designing shift schedules or making changes to current roster patterns. However, biomathematical models do have several limitations, such as only considering potential fatigue, and generally requiring some background knowledge or understanding of fatigue and sleepiness in order to adequately interpret results. Importantly the person implementing the model should be fully trained in its use and interpretation. The models should not be used in isolation, but within a comprehensive fatigue management system. The majority of models have been validated or used within shift work populations, therefore there would be applicability for use within this industry, however to date, there is limited evaluated use of biomathematical models specifically to bus drivers. The use of bio-mathematical models of fatigue have grown in popularity, with reported use in several transport industries. Within aviation, work has been conducted comparing various commercially available biomathematical models for use within a comprehensive fatigue risk management system (Civil Aviation Safety Authority, 2014), and it is thought that within the UK rail industry, the most widely used fatigue model is the HSE FRI (Bowler and Gibbon, 2015).

- **Protecting break and rest times**
  Research has indicated the importance of rest and break time during and between duties, to ensure that drivers are alert and adequately rested. It has been shown that time on shift increases the risk of a fatigue related incident (Folkard & Lombardi, 2006; Hänecke, Tiedemann, Nachreiner & Grzech-Šukalo, 1998; Nachreiner, Akkermann & Hänecke, 2000; Wagstaff & Lie, 2011), and adequate rest breaks are a crucial element of fatigue mitigation. Drivers are allocated a break during their shift, e.g. for lunch, which usually approximately 1 hour. In addition, there is 'recovery time' at the end of each route, built into the schedule with the aim of accounting for delays. Regardless of the length of lunch break offered by an operator, 40 minutes of this time is protected (which is 10 minutes more than the GB domestic drivers' hours require). Data from focus groups, manager interviews, and the online survey highlighted that the recovery time can sometimes be infringed upon, impacted by situations such as late running times. However, from the research conducted, it was clear that the infringement on the recovery time was perceived by the drivers as an infringement

on their break time. This difference between what is defined as a break versus what is defined as recovery time and perceived breaks should be addressed to avoid confusion and to help drivers plan and manage their breaks, rest, and the use of any individual countermeasures to fatigue. Providing adequate breaks and rest could allow for napping and healthy eating and reduce stress for drivers. In terms of rest between duties, there should be protection surrounding time for drivers to commute to and from work, sleep and rest, eat, and have adequate family time, which should also ensure drivers are sufficiently rested and reduce their stress and improve their well-being.

- **Ensure that schedules are better matched with actual running time, at all times of day**
  Linked to protecting break and rest times, increasing the running times during peak hours was a solution raised from the focus groups, survey and literature review. It was reported that during these peak periods, it can be difficult to complete routes in the allocated time due to pressures e.g. volume of traffic, with added factors such as roadworks and congestion, a common occurrence in city centre driving. Schedules should be reflective of the 'real world' and introducing dynamic scheduling, for example allowing additional running time during busy periods so drivers are not rushing, and likewise reviewing schedules to make sure time is used efficiently, would help to reduce driver stress, and ensure turnaround times are manageable. Consequently, the relationship between drivers and traffic controllers may also be improved. Although the focus of the solutions is fatigue, it is recognised that when considering mitigation strategies, there are other business factors which also need to be balanced.
- **Providing more flexibility regarding drivers' shifts**
  Data from the focus groups and manager interviews highlighted the desire for greater flexibility regarding shifts, although this would need to be considered in terms of safety and fatigue. **Considering the chronotype of the driver** when designing rosters may also be a fatigue mitigation strategy, for example, allocating a fixed roster to match a person's chronotype. The chronotype of an individual, that is, whether they are a morning type or an evening type, is related to their underlying circadian rhythms and preference for sleep during a 24-hour period. For example, a morning type may prefer to go to bed early and get up early, and feel alert in the morning, whereas an evening type may prefer to go to bed later and wake later and feel more alert in the evening. In terms of shift work, morning types may find it easier to obtain adequate sleep prior to early morning shifts, whereas an evening type may struggle. However, it may also be that drivers prefer rotating shifts, and that they are able to manage their rest well around them. If drivers are able to select their own hours or shift preference, individual motivation may need to be considered, as a driver may look to try to maximise their time off by condensing their work time, or may choose shifts based on their social and/or family life, both of which may increase fatigue risk. It is positive to allow some degree of flexibility, however there should be some limitations, and consideration would need to be given to how this is achieved. Furthermore, it should be acknowledged that there is a balance to be struck between flexibility and running an efficient operation, so although some flexibility may be allowed there will necessarily be a limit (due to the time required competing with the other duties managers have) to how flexible operators can be.

4.4.3 Potential for reducing driver fatigue

Implementing changes to schedules and rosters is likely to be effective at reducing driver fatigue. Similar to the establishment of, and access to, facilities, schedule and roster design is often out of the control of the driver, which could potentially impact stress levels. Several of the proposed schedule and rostering solutions would have a direct effect on driver fatigue, for example enabling

drivers to plan and manage their rest both during and between duties. However, changes need to be considered with safety in mind, and education may be required to encourage engagement with any proposed changes, and to ensure drivers know how to effectively manage their rest and are motivated to do so. Making fundamental changes to rosters may also have several limitations from a driver point of view. Introducing certain rostering practices such as limiting the number of consecutive earlies, may have a significant impact of the working life of the bus drivers, for example reducing the flexibility in their rosters, and potentially limiting their financial options by restricting overtime allowances. Therefore, certain proposed changes could be met with resistance, with the need for balance between fatigue mitigation, operational need, and driver satisfaction.

4.4.4 Anticipated time to introduce

The anticipated time to implement solutions relating to schedules should be relatively short term, as the techniques and resources are already in place to design schedules. However, this would depend on the time to review the potential solutions before they can be implemented and whether additional resources are needed. It may also be that changes require the agreement of several parties, which may take additional time to discuss, negotiate, and agree.

4.4.5 Indication of cost

Implementing solutions relating to schedules and rosters would require some additional operator and employee time, and possibly additional training. It would also depend on the level at which each of the solutions is addressed, as several of the solutions may impact operations and require additional employees or buses, and therefore the costs may vary. If changes require considerable re-engineering of work practices and pay structures to make any meaningful impact, then both time and cost may increase significantly. In the first instance, time to introduce new rosters and/or schedules may be short, however any fundamental changes would most have significant cost and resourcing implications.

4.4.6 Effort required to achieve the full potential to reduce driver fatigue

Reasonable effort would be required to achieve the full potential of reducing driver fatigue. Although the majority of resources may already be in place to begin implementing solutions relating to scheduling and rostering, any changes need to be considered in terms of safety, exploring the impact of and any limitations to, the proposed solutions. If solutions are not considered, there is a chance any changes may have a detrimental effect, possibly increasing fatigue resulting in driver reluctance to engage with future fatigue mitigation strategies.

4.5 Open culture

	Potential for reducing driver fatigue	**Anticipated time to introduce**	**Cost indicator**	**Effort required to achieve the full potential to reduce driver fatigue**
Open culture	****	**Long term**	**£-£££**	●●●

4.5.1 Overview

It is important that when managing fatigue and sleepiness and attempting to mitigate fatigue risk, individuals feel supported, moving away from the notion of a discipline-based culture. Therefore, it is important to establish an open culture in terms of fatigue. It is likely that everyone will experience aspects of fatigue at some point, whether through scheduling, poor sleep, or family/social

circumstances, so it is important that a system is in place to manage this and offer support to the individual. Recently there has been a move toward establishing evidence-based safety cultures, (Lerman et al., 2012) emphasising data driven continuous learning, with a positive safety culture supported by management commitment. However, to implement an effective fatigue system, open culture needs to be established, encouraging reporting and engagement with changes and initiatives. Input, cooperation, and open discussions from various stakeholders (e.g. employers, workers, occupational health and safety professionals and policy makers), are vital components of establishing an effective fatigue management system (Wong et al., 2019). In terms of many of the proposed solutions related to open culture, it is suggested that TfL and operators discuss these with other companies that have achieved an open culture, or started to implement elements of this, this will allow them to gain first hand advice that is unlikely to be covered within the scientific literature.

4.5.2 Proposed solutions

- **Fatigue risk management**
  In recent years, emphasis has been placed on fatigue risk management (FRM), with the encouragement of evidence-based safety management systems, risk assessments, and mitigation strategies tailored to specific company policy, all supported by management commitment to a positive safety culture (Lerman et al., 2012). Fatigue risk management systems (FRMS) are beneficial as they allow for the flexible management of fatigue, moving away from more prescribed operational approaches (Gander et al., 2011). The main consideration with FRM should be the assessment and mitigation of fatigue risk, although the systems to achieve this can vary. However, there is the potential for FRM to be abused, or become a tick box exercise with no oversight, both of which should be avoided. Data from the policy review, focus groups, and manager interviews highlighted the need for an established fatigue management system, incorporating reporting, monitoring, and mitigating of fatigue risk. A full FRMS should include clear policy's for reducing the chance of fatigue, processes for managing and reporting it if fatigue occurs, and follow up evaluation of any fatigue occurrence to inform future improvements of the FRMS.
- **Moving away from a system which is only designed to deal with discipline**
  For an open culture to be successful, there should be a move away from a discipline-based culture, to encourage individuals to engage with their employer and feel supported when reporting, discussing and contributing to fatigue related processes. For example, data from the focus groups and manager interviews highlighted that drivers may be hesitant to report or discuss fatigue events to the same person who has responsibility for discipline related proceedings. Several research tasks have also highlighted the importance of establishing a system to monitor fatigue incidents, with the **ability to report a near miss due to fatigue**. However, before fatigue reporting is encouraged, it is important that drivers have the ability to, and the motivation to, report near misses in general. This encouragement will come from establishing an open culture and moving away from a discipline-based system, with research indicating that perceptions held by employees of management safety practices within the trucking industry were predictive of fatigue reporting and near miss reporting (Morrow & Crum, 2004). Monitoring fatigue is necessary in terms of informing changes to policies or procedures, to identify issues relating to fatigue, and reviewing and evaluating any fatigue mitigation strategies. By establishing an open culture surrounding fatigue reporting, drivers should be encouraged to report related incidents so that they can be reviewed, and any support can be offered in terms of managing fatigue in the future. Moving away from a discipline-based system will take extensive time and involve commitment from all parties.

Relationships and trust will need to be developed in order to encourage reporting without fear of disciplinary action.

- **Improving the relationship between drivers, managers, and traffic controllers**
  Focus groups, and manager interviews indicated tension and stress surrounding relationships between the drivers, managers, and traffic controllers, which potentially could impact fatigue levels. It is important to understand the cause of this tension, and look for ways to improve the relationships, to help reduce driver stress and fatigue levels.
- **Openness to new technology**
  In recent years there have been developments in the use of technology to detect and monitor fatigue states. There are numerous systems available which have been briefly covered in section 3.1.1.3.3 (see Dawson et al., 2014 for a review on fatigue monitoring technologies across various driving domains), however, an extensive review of fatigue countermeasure technology has not been conducted as part of this research. Many of the fatigue systems have not been independently evaluated, and therefore the suitability in relation to reducing fatigue in bus drivers is unknown. It is possible that the current systems are not sophisticated enough to detect and monitor fatigue (Dawson et al., 2014), however, with technological advancements, this may become increasingly possible. Nevertheless, it is important to stay open to new and emerging technologies, although several considerations should be made when choosing/implementing fatigue technology, including validity, reliability, generalizability and predictability (Dinges, Mallis, Maislin & Powell, 1998; Kerick, Metcalfe, Feng, Ries & McDowell, 2013). If people do not engage with new technology, it becomes difficult for suitable systems to be developed. Furthermore, it is important that these systems are used in an open culture and are not used in relation to discipline and discipline monitoring activities. It should be noted that the available technology would not prevent a fatigue event from occurring, but rather alert the driver when they have experienced a fatigue event. This therefore may prevent an accident, however, would not prevent the fatigue event itself, which highlights the importance of establishing an open culture to be able to use the technology as a preventative strategy.
- **The formation of a fatigue working group, including input from drivers**
  Research indicates that effective fatigue management includes views and inputs from all individuals, with focus group data suggesting that drivers sometimes feel omitted from these discussions. The establishment of a fatigue working group that includes representatives from the bus drivers and additional stakeholders, such as union representatives, will encourage an open culture relating to fatigue. The development of this group would provide drivers with the opportunity to express their views and be included in the decision-making process, as well as provide operators and TfL the opportunity to hear how fatigue and relevant policies directly effects the drivers, and any issues there may be. This could also be an opportunity to involve drivers in the development of new schedules or working time arrangements, or participation in the implementation of new shift systems. It is proposed that successful working groups or fatigue steering groups include balanced representation from all parties, including the company and employees (Gander et al., 2011).

4.5.3 Potential for reducing driver fatigue

Although this solution has not been formally evaluated, establishing an open culture has the potential to be effective at reducing driver fatigue. Previous research has shown that workers who feel that their company has an open safety culture are less likely to experience fatigue, engage in

fatigue-related driving behaviour, and encounter near misses when driving as part of their work (Morrow & Crum, 2004; Strahan, Watson & Lennonb, 2008). Developing an open culture is linked to many proposed solutions, and has the potential to encourage reporting, discussions relating to fatigue, sleep and health, and an openness to new systems, policies and procedures. Individuals should feel supported in aspects relating to fatigue, with the emphasis shifting away from a discipline-based system. Fatigue risk should therefore be mitigated by drivers being able to openly discuss fatigue and any issues they face without fear of negative consequences, and should engage with other aspects of the system, enabling operators to monitor incidents, and introduce additional proposed solutions. However, if individuals do not engage with the process, then it may be difficult to achieve results.

4.5.4 Anticipated time to introduce

The anticipated time to introduce and implement potential solutions relating to open culture is most likely lengthy, due to the on-going and progressive nature of the overall theme. Although introducing the notion of an open culture within London bus drivers may be relatively short term, an effective open culture should be constantly developing and improving and will require engagement from all parties involved.

4.5.5 Indication of cost

The potential cost of implementing solutions related to open culture ranges depending on how the solutions are addressed. For example, encouraging engagement with an open culture, establishing fatigue working groups, and moving away from discipline-based cultures may have minimal cost, however future advancements and implementation of technology may require substantial cost.

4.5.6 Effort required to achieve the full potential to reduce driver fatigue

In order to implement an effective open culture, maximum effort will be required to achieve the full potential of reducing driver fatigue. All parties will need to be involved and engaged with the process, encouraging a positive and open safety culture and fatigue risk management system. Establishing an effective open culture will take time and will be an ongoing process. Effort will be required throughout to encourage engagement, and to ensure that the system is continually developing and incorporating learnings. Therefore, results may take time and benefit may be difficult to achieve without full commitment to change and individuals embracing the ongoing nature of the system.

4.6 Health (including sleep health)

	Potential for reducing driver fatigue	**Anticipated time to introduce**	**Cost indicator**	**Effort required to achieve the full potential to reduce driver fatigue**
Health (including sleep health)	**	Medium term	££	••

4.6.1 Overview

Overall health and well-being of workers, including aspects of sleep health, are important elements of shift work, and can impact job performance, sleep, and safety. Research with bus drivers has shown correlations between BMI and sleepiness (Santos et al., 2013), and that factors such as poor

sleep quality, insomnia and high obstructive sleep apnoea (OSA) risk are associated with excessive daytime sleepiness (Kim et al., 2017). Implementing strategies to encourage and support improvements in health therefore have the potential to mitigate against fatigue.

4.6.2 Proposed solutions

- **Reducing stress and workload pressure whilst driving the bus**
  Findings from the literature and from the research conducted in this body of work indicated that stress is a major part of the job of a bus driver, occurs frequently, and is a risk factor for fighting sleepiness. Implementing solutions aimed at reducing stress, particularly on-road, could potentially have a large impact on drivers and potentially lead to reductions in fatigue. Solutions to reduce stress would be linked to education, working conditions, and scheduling.
- **Improving the general health of drivers**
  From the research conducted, the driver survey data indicated that the general health of bus drivers was a risk factor for fighting sleepiness. Therefore, general health promotion at the operator level and implementing solutions to improve health, possibly through facilities, education, awareness, and opportunity and access, could lead to potential reductions in fatigue. Examples may include free step counters for drivers, promotion and support for online training in aspects of sleep and health, or encouraging exercise, possibly through the organisation of group events. A literature review examining health promotion amongst truck drivers has shown that interventions lead to positive outcomes (Ng, Yousuf, Bigelow & Van Eerd, 2015), whilst a randomised control trial involving pilots found that those using a mobile application which aimed to improve general health had less self-reported fatigue than those in a control condition (van Drongelen et al. 2014).
- **Providing health screening**
  Research has suggested health screening targeted as those at most risk of fatigue, such as those with OSA and other sleep disorders (Hakkanen & Summala, 2000), would enable individuals to receive the support needed to address and manage any resulting issues. In the case of OSA, treatment outcomes are often positive with adherence to the treatment regime (Belenky, Wu & Jackson, 2011), with evidence of reductions in motor vehicle accidents following treatment of OSA (Mazza et al., 2006), highlighting the effectiveness and importance of diagnosis and treatment. Health screening could be part of a regular company check, or a one-off site visit.
- **Training for medical practitioners**
  Linked to health screening, training medical practitioners in elements such as the signs of excessive daytime sleepiness, risk factors for OSA, and appreciation of driver safety can ultimately benefit individual drivers and help to improve health and well-being. In providing training for medical practitioners whom drivers interact with, they will be better able to identify the signs of excessive sleepiness and provide suitable advice to mitigate this. For example, this could be achieved by operators contracting medical screening, or by TfL providing provision and/or information about driving days for doctors. The majority of operators currently contract out health screening to private providers, therefore it should be reactively straightforward to ensure that these providers have fatigue and shift work expertise. However, many drivers may also visit their GP for fitness certificates, or just for health checks, and increasing GP understanding of fatigue is more difficult to influence.
- **Tracking sleep health**
  Implementing systems which allow for the tracking and monitoring of overall sleep health was a solution generated from the manager interviews and the on-road study. There are various means of achieving this, from technological monitors (e.g. Actiwatches or

Readibands) to asking drivers about their sleep, with the important factor being the establishment of system or process in which general sleep is discussed, and sleep issues can be reported. However, before implementing an initiative aimed at tracking sleep health, and to increase driver engagement, an open culture needs to be established, which has moved away from a system based around discipline. By generating an open culture, individuals should hopefully feel supported enough to report sleep issues and have regular discussions relating to sleep health.

4.6.3 Potential for reducing driver fatigue

Implementing solutions to help improve the health of bus drivers could offer potential for reducing driver fatigue, however, the effectiveness may be dependent on several factors, with different methods and strategies producing different results. Educating drivers on the benefits of health and associated risk factors, providing facilities to support health improvements, as well as establishing an open culture enabling drivers to feel comfortable reporting and discussing fatigue and health issues possibly are important steps to reducing driver fatigue. However, like education, changes to health, and engagement with health strategies requires individual motivation, and therefore results may be difficult to achieve. If drivers decide to engage with implemented practices aimed at addressing overall health, then the potential to reduction in driver fatigue will be minimal.

4.6.4 Anticipated time to introduce

The anticipated time to introduce will depend on how the area of health is addressed but will most likely be medium term. It will depend on the time taken to develop strategies to address the proposed solutions and how quickly these can be implemented or organised.

4.6.5 Indication of cost

The cost of addressing health to potentially mitigate fatigue would require additional operator and employee time, and potentially additional facilities, equipment, training, and publicity. It would also depend on what level each of the solutions are addressed, and therefore the costs may vary.

4.6.6 Effort required to achieve the full potential to reduce driver fatigue

The effort required to achieve the full potential to reduce driver fatigue is again dependent on the solutions that are implemented. Supporting drivers and encouraging engagement with new policies relating to health and well-being, eating, stress, and screening would take effort in order to be effective, however again requires motivation from individual drivers to achieve possible results. There is also a shared responsibility component in order to potentially achieve a reduction in driver fatigue, with operators and TfL reviewing and implementing potential health solutions, and drivers taking responsibility for their health and utilising facilities and educational strategies to ensure they are fit for work.

4.7 Conclusion

This section aimed to discuss the proposed solutions to potentially reduce fatigue in London bus drivers. Five themes emerged from the research, (education, working conditions, schedules, open culture, and health) with respective solutions fitting within these themes. The proposed solutions were informed from the literature review and the five research tasks conducted as part of this body of work, and only those solutions with potential for reducing driver fatigue have been included in the report. Several of the solutions and overall themes overlap or complement each other, supporting the notion of a holistic approach, encompassing or addressing aspects of each of the themes, to provide the most benefit in terms of reducing fatigue.

It should once again be noted that none of the proposed solutions have been formally evaluated. Therefore, if any of the solutions are implemented, it is strongly recommended that an evaluation into the effectiveness of the countermeasure is conducted. This would require a monitoring system, and an open culture to establish engagement with the process. Reducing fatigue is also a long-term commitment with no quick fix; solutions need to be implemented in a step-by-step approach with small changes to be accepted by drivers before a more sophisticated solution is implemented over time. It is important that parties do not give up too early, especially as in the first instance there may be some resistance to change.

Although the themes were not ordered in terms of importance, it is clear that establishing an effective open culture underpins many of the proposed solutions. Strategies such as establishing a reporting system to monitor fatigue or creating rest facilities for napping will not be effective if there is no overarching open culture, where individuals feel supported in discussing fatigue and implementing strategies related to health and well-being. It is important to note that all parties (drivers, managers, operators at all levels, TfL, borough councils, unions, and the Department for Transport [DfT]) are involved in all aspects of fatigue management and that everyone has a part to play. However, this does add to the complexity of implementing potential solutions. In relation to fatigue and fatigue mitigation, everyone has a responsibility, and for the full potential to be reached of reducing driver fatigue, commitment to the process and engagement with the system needs to be achieved by all.

5 Limitations and future research requirements

5.1 Limitations

As with all research the findings should be considered in context of the limitations. One limitation of the current research related to the participants and sample size. Although drivers from all 10 operators were involved to some extent throughout the research project, the representativeness of the sample differed between tasks. In the focus groups one group of drivers which were not widely investigated were night drivers. Although some night drivers participated in the focus groups, in most cases night drivers only work nights, and would therefore have been unavailable to take part in our discussion groups as these occurred during the day.

With regard to the survey, although a final responding number of 1,353 is fairly large, this is from a total population of roughly 25,000 London bus drivers. There is a possibility that those who responded to the survey were the drivers who had strong views on fatigue that they wished to convey. However, there were a number of survey respondents who indicated that fatigue was not a problem for them, making it unlikely that only drivers suffering from fatigue/ sleepiness chose to respond to the survey. It is also possible that those who chose to complete the survey are particularly worried about, or interested in, fatigue. Another potential limitation to the survey sample is that the number of respondents working for each operator differed greatly. To some extent this is an artefact of the size of the operator, with a greater number of participants working for the larger operators. Additionally, variability in the steps taken to promote the survey between each operator would likely influence uptake.

Another limitation of the current research relates specifically to the on-road study. This study was the first of its kind to investigate fatigue on a live bus in such a busy location. However, due to the nature of real-world research, the on-road study came with a variety of logistical challenges which interfered with data collection. These issues were mainly related to the instrumented buses which often became unavailable due to mechanical faults or scheduling changes at the operator. This proved challenging as the study involved collecting data without impending the daily running of the bus service. As such, there were several instances in which full data sets could not be collected. The challenges experienced in this study demonstrates why this kind of research has not been conducted before. The fact that the current research is so novel and unique is why the work is so important and ground breaking.

A second limitation of the on-road study relates to the self-reported sleepiness and stress scores. Before each drive, participants were reminded to report their sleepiness score followed by their stress score. However, as the researchers did not want to interrupt the participant whilst they were driving, participants were not reminded of this order every time they reported their scores. There is therefore a possibility that drivers may have reported these scores in the wrong order.

A general limitation is that the current research did not focus on any particular cultural or religious events, such as Ramadan, which many drivers may observe. The observance of such festivals may lead to potential further fatigue as a result of dietary requirements, however data for all of the research tasks was collected outside of this time period.

A final limitation in this project relates to the proposed solutions. As discussed in section 4, the solutions proposed in this report have not yet been evaluated. This is because the research into bus driver fatigue is currently very limited. As such, the potential effectiveness of each solution has been determined by the expertise of the research team as opposed to controlled experimental research.

5.2 Future research

In linking further research to the limitations of the current project, the first potential for future research would be to implement and evaluate the potential solutions discussed in this report. In order to establish the effectiveness of any solution, a formal evaluation should be conducted. This should occur by either comparing driver fatigue before and after the implementation of a given solution, or through a randomised control trial in which one group are given an intervention whilst another is not. By doing this it would be possible to establish just how effective a proposed solution is at reducing bus driver fatigue.

There are several other avenues for potential future research in this area, these include:

- Expanding the on-road study by collecting further data.
- Exploring the relationship between bus drivers, and controllers (an issue which arose in several research tasks in the current project).
- Including shift schedulers in the research.
- Investigating fatigue/ sleepiness specifically amongst night bus drivers.
- Conducting a dedicated evaluation on fatigue detection technology currently available.
- Considering the differences in fatigue between intercity and suburban bus routes.
- Exploring the differences between experienced and inexperienced bus drivers.
- Comparing, and learning from, fatigue policies used in other transport modes such as rail and trucking.

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8 Appendix

Appendix A: Summary of the 26 papers specifically considering fatigue or sleepiness in bus drivers included in the literature review

Fatigue experience in bus drivers			
Reference	**Method**	**Main Results**	**Key Discussion/Conclusion**
Biggs, Dingsdag, & Stenson (2006)	Questionnaire	Several fatigue variables were indicated, including unrealistic schedule, cabin ergonomics, and shift cycles.	The impact of all factors was discussed. Amongst these, two stand out: fatigue related to unrealistic scheduling and the effect of managerial support on fatigue.
Biggs, Dingsdag, & Stenson (2009)	Semi-structured interview – focus groups	Nine causation factors were identified.	1) support from management 2) ticketing issues 3) interaction with passengers 4) cabin ergonomics; 5) tight route schedules 6) turn-around and shift irregularity 7) extended shift cycles 8) interactions with other road users 9) extended commute times
Vennelle, Engleman, & Douglas (2010)	Questionnaire	20% of drivers reported ESS>10, 12% of them fell asleep at the wheel at least once/month, 7% had had an accident, and 8% of them experienced a near miss due to sleepiness while driving.	Results showed a high rate of sleepiness and sleep-related accidents amongst bus drivers, as well a potentially high rate of obstructive sleep apnoea/hypopnea syndrome (OSAHS).
Sando, Mtoi, & Moses (2010)	Questionnaire, and analysis of incident reports and operator schedules	Drivers under split shift are more susceptible to fatigue, with inadequate rest time possibly contributing to fatigue.	Suggested that the bus operators implement fatigue detective technologies as well as improved policies.
Liendo, Castro, & Castro (2010)	Questionnaire	43% to 48% of the bus drivers sleep less than 7 hours a day. The most frequently admitted time of the day for having or	The fatigue and sleepiness levels were similar between formal and informal drivers.

		almost having an accident was 0100 to 0400 in the morning. 16% had levels of sleepiness.	
Abdullah & Von (2011)	Questionnaire	Bus accidents were significantly related to working schedule and working conditions.	That the buses, working schedule, and working conditions need to be improved to reduce the accident rate in Malaysia.
Diez et al. (2011)	Multiple methods including questionnaire, actigraphy, heart rate recording during a shift, PVT	Under sleeping was noted particularly amongst drivers working morning shifts. This group also showed slower reaction times.	Sleep hygiene and sleep education are needed to ensure that drivers are fully alert during their duty.
Mohamed et al. (2012)	Qualitative impact assessment	The consideration to ban early-hour schedules could result in further negative impacts on overall road safety, if aspects such as driving and work hours, and the need for driver rest facilities, are not addressed.	Highlights the need for a more holistic approach to prevent fatigue-crashes in Malaysia.
Makowiec-Dabrowska et al. (2015)	Questionnaire (Fatigue test questionnaire)	The fatigue profile after work was significantly higher than before work, but was not affected by route type. 7 fatigue symptoms were significantly higher after the “difficult” route. The level of fatigue was correlated with job characteristics.	The relationship between fatigue symptoms, job features, and lifestyle indicates both employees and employers are responsible for fatigue in bus drivers. The questionnaire used is a sensitive and useful tool for bus driver fatigue assessment.
Anund, Ihlström, Fors, Kecklund, & Filtness (2016)	Questionnaire	Driver sleepiness is prevalent among city bus drivers. 19% of drivers had to fight to stay awake whilst driving the bus 2-3 times/week +, and 45% 2-4 times/month.	Severe sleepiness was common amongst city bus drivers. Highlighted the importance of mitigating driver sleepiness and the need for fatigue risk management programmes for city bus drivers, involving

			organisational and individual countermeasures.
Deza-Becerra et al. (2017)	Questionnaire (inc. Epworth Sleepiness Scale)	9% of drivers slept less than 6h/day. 74% drivers experienced fatigue, 25% drivers experienced sleepiness, and 35% drivers had experienced nodding, while driving. Nodding and experience of driving (years) were associated with an accident or near miss. Drivers often slept in inappropriate places which impacted sleep quality.	Fatigue and sleepiness, as well as accidents or near misses occurred frequently in bus drivers. Highlighted the need for an improved system which ensures adequate rest for drivers, guidelines for schedules, and educational interventions.
Ihlström, Kecklund, & Anund (2017)	Questionnaire	36% of drivers reported split-shifts to be an issue, reporting poorer health, increased stress, interference with social life, reduced sleep quality, persistent fatigue, and lower general work satisfaction compared to those who did not find split shifts a problem.	In general, split-shift work schedules were not associated with increased stressed, poorer health and negative psychosocial work factors. However, individual differences were important as 1/3 reported problems working split shifts and experienced the above issues.
Lee, Kim, Byun, & Jang (2017)	Questionnaire (inc. Karolinska Sleepiness Scale)	No statistical differences between KSS scores for first and morning periods. Alternating day shift associated with severe sleepiness from lunch to last driving period.	Alternative day shift drivers experienced more irregular work schedules and longer working hours, and therefore suffered from more sleepiness.
Ahlström, Lövgren, Nilsson, Willstrand, & Anund (2018)	Field Test (Eye tracking, physiology, subjective rates, and video)	Dynamic steering significantly reduced required muscle activity while turning.	Muscle activity was reduced due to the use of dynamic steering, and the bus drivers believe the incorporation of this steering would reduce neck and shoulder issues.

Anund, Fors, Ihlström, & Kecklund (2018)	Real-world bus test (using EEG, camera, and KSS)	An increase in sleepiness was experienced in the afternoon by those drivers who had worked that morning, compared to being off duty in the morning. Vigilance response also significantly increased with split shift working.	Drivers working split-shifts experience sleepiness during the afternoon. Countermeasures are needed to ensure safe driving during split-shifts.
Kim, Jang, Kim, & Lee (2018)	Real-world bus test (using heart rate measures, and the Fatigue Risk Index, FRI)	Actual working hours of drivers were longer than the maximum acceptable working time (the maximum time workers can sustain their workload without physical fatigue). Fatigue index of WR schedule (every other day) was high, ranging from 45.2 to 54.4, and risk index was 1.8, which was higher than other schedules.	The WR schedule (working every other day) caused over work in drivers and showed high fatigue and risk scores according to the fatigue and risk indices. Regulations and policies for drivers working time should be reviewed. Restricting driving time may help to reduce driver fatigue and the risk of accidents.
Chaiard, Deeluea, Suksatit & Songkham (2019)	Survey made up of three questionnaires (sleep quality, risk of sleep apnoea, sociodemographic, lifestyle behaviours and work data)	60% of drivers reported poor sleep quality. An increased risk of poor sleep quality was predicted by marital status, alcohol consumption, lack of exercise, night driving, and rotating shifts patterns.	There is a high prevalence of poor sleep quality amongst Thai bus drivers, this is likely caused by a combination of factors which includes shift work.
<u>Fatigue countermeasures and prevention strategies for bus drivers</u>			
Reference	**Methods**	**Main Results**	**Key Discussion/Conclusion**
Machin & Hoare (2008)	Questionnaire	That workload was an important predictor for the drivers' need for recovery.	Fatigue management strategies should focus on the assessment and remediation of bus drivers' response strategies.
Razmpa, Niat, & Saedi (2011)	Questionnaire (inc. Epworth Sleepiness Scale,	Sleep problems were a common occurrence amongst drivers, and had a	The results highlight the importance of sleep in relation to bus driving. Attention needs to be paid

	insomnia, and apnoea index)	significant relationship with crash history	to treating sleep disorders, as well as occupational sleep hygiene of bus drivers.
Sang & Li (2012)	Experimental testing (Psychology Fatigue Measurement System)	The bus driver's performance decreased over time in terms of 4 indicators: flash fusion frequency, reaction time, speed perception, and attention level.	That bus driver's reaction time began to decrease sharply after 4 hours of duty.
Santos, Bittencourt, de Assis Viegas, & Gaio (2013)	Questionnaire (inc. Epworth Sleepiness Scale), and attention tests	Drivers' sleepiness was correlated with BMI, and attention level was correlated with age.	Sleepiness is a common risk factor for professional drivers.
Wang & Wang (2013)	EEG analysis in real driving environment and questionnaire	The relationship between driver fatigue and associated EEG characteristics are analysed.	Driver fatigue state changes can be effectively detected through EEG fatigue state index F.
Krishnaswamy, Chhabria, & Rao (2016)	Questionnaire (inc. Epworth Sleepiness Scale)	Although 62.8% of drivers experienced sleepiness, no drivers reported causing accidents due to sleepiness. Various coping strategies are mentioned. Post-shift sleep was studied, concluding that initiating and maintaining sleep are major issues.	Night bus drivers have a high incidence of night-time sleepiness and daytime sleep disruptions. Highlighted the need for shift work education and alertness testing for shift workers in critical professions.
Mandal, Li, Wang, & Lin (2017)	Vision-based fatigue detection system	The proposed method was able to distinguish the drowsy and sleepy states compared to normal states of driving.	The system may be able to monitor driver's attentional levels effectively without additional cameras.
Kim et al. (2017)	Questionnaire	Out of 842 bus drivers, 13.2% reported ESS score >10, 68.4% experienced poor sleep quality, and 10.2% had a	Poor sleep quality, insomnia and high risk for OSA are three factors associated with excessive daytime sleepiness amongst Korean bus drivers.

		moderate to severe insomnia.	
Wang & Wu (2019)	Schedule analysis, case study approach	Driver scheduling of multi-day driving patterns effects driver's crash risk. Driving in the afternoon or early morning for two consecutive days, and following 24h rest, returning to work in the morning, afternoon, or early morning were patterns with the greatest crash risk. Rescheduling may help to reduce overall fleet crash risk.	A mathematical optimisation model was developed. Rescheduling using the developed could reduce the crash incidence by approximately 30%. Highlighted the need for further research into why multi-day driving patterns are associated with higher crash risk.

Appendix B: Bus driver focus group question guide

Introduction

- Welcome and thanks for coming
- Introduce X and X – Loughborough's role – project overview - discussion groups to get driver perspective on what it is really like.
- Informal discussion about your experiences of fatigue and how it is managed at work – your feedback is really important for the future fatigue management in the industry, so please feel free to have your say and be honest.
- For us it is important that you talk to each other and share experience, we are only observing and not the experts. You are.
- All information you provide will be kept confidential, no individuals will be identified in any reports
- Can we audio record the discussion?

Introductory Question

- Before we go into specific fatigue questions, we'd just like to learn a little bit about you and your backgrounds, whatever you're prepared to share. We are interested in what brought you to into bus driving, how long you've been driving buses and what shift pattern are you working?

Does fatigue occur, is it a problem

- If I say 'fatigue' what do you think about? [PROJECT DEFINITION: a psychological and/or physical impairment experienced by a driver which has the potential to reduce optimal performance. Fatigue is considered to be multifaceted, encompassing pressures from both the sleepiness related to human biology and task related fatigue. So it may be:
  - Sleepiness due to insufficient sleep and/or time of day
  - Task related fatigue due to the nature of work driving a bus in city environment resulting in an inability to continue or impairment in performance caused by
    - Time on task due to the same activity going on too long
    - Overload of cognitive demands during times of exposure to demanding workload.
    - Underload of cognitive demands during times of monotonous activity.
    - Physical muscle fatigue due to physical exertion, for example steering the bus.]
- What has been your general experience of fatigue at work? Could you describe a situation where you or anyone you know has suffered from driver fatigue during work?
- To what extent do you believe fatigue/sleepiness is a problem in your industry?

Consequences of fatigue

- In what way do you think fatigue/sleepiness influences safety at work?
- What is your biggest safety concern if you are fatigued/sleepy at work?
- How is your driving affected when you feel fatigue/sleepy? In what way do you notice a difference in yourself and your driving when working days you feel very alert compared to days when you feel sleepy?

Strategies for managing fatigue

- Do you take any measures to ensure you are not fatigued/sleepy at work? PROMPT: plan to sleep before shifts, drink coffee, etc.
- What do you do if you feel fatigued/sleepy?
- Could you please describe how you prepare yourself to avoid fatigue/ sleepiness before a shift?

Causes of fatigue

- What issues might cause you to be fatigued at work?
- Does the route you drive cause you stress/fatigue? Is there a difference when it is a new route or one you drive regularly?

Workplace culture surrounding fatigue

- What would you do if you felt fatigued/sleepy at work?
- Could you describe how you communicate with your employer or supervisor if you were fatigued/sleepy at work? What would you expect their response to be?
- What do people do if they are too tired to work? PROMPT: Would you phone in sick? Would you say you were tired or give a different reason?

Shift patterns/overtime

- Are shift patterns fixed or can you/do you swap shifts? How does this influence fatigue?
- Are there any specific times of the day, situations, or points in a shift/shift pattern when you are most likely to feel fatigued/sleepy or that your alertness is particularly challenged?*
- From experience can you tell us which features of rotas cause you the most fatigue? E.g. changing start times, rotation through earlies, middles and lates, or rest days being reduced by long shifts either side.
- How much extra overtime can you pick up? Does this influence your fatigue?

- Does anyone check your total hours resulting from overtime? What motivates your choice of how much overtime to take on?**

Sleep/fatigue outside work

- Does your non-work time (including commute) influence how fatigued/sleepy you feel?
- What factors influence how much you would sleep when not at work?
- Can you describe how you switch off and relax at the end of the day after work?

Stress/pressure

- What aspects of the job are most stressful for you? Do these link to feelings of fatigue?
- Do you feel under pressure to meet the route timetable? How does this affect your stress/fatigue?

* **Need to find this out for the on-road study**
** **Do any swap on purpose to end up below the minimum hours to get paid for not working? Only applies where there is a minimum wage.**

BACK-UP QUESTIONS:

- How much notice do you get about shift pattern/holiday allocation? Is there any flexibility to swap?
- Has your attitude and approach to picking up overtime changed over time? If yes, what factors have influenced it?
- Are the ways you cope with fatigue individually developed, learnt from colleagues, or taken from advice from your employer?
- Have you had training/advice on how to handle fatigue? If not, would you like some, and what would you like it to cover?
- Could you describe your view on violence and threats at work, and how these influence you?

Closing

- Any other comments/questions?
- Thanks

Appendix C: Manager interview question guide

Introduction

- Thank you for agreeing to the interview
- Introduce yourself – Loughborough's role – project overview – interviews to get manager perspective on workplace culture around fatigue
- Informal discussion about your experiences of fatigue and how it is managed at work – your feedback is really important for the future fatigue management in the industry, so please feel free to have your say and be honest
- All info you provide will be kept confidential, no individuals will be identified in any reports
- Can we audio record the discussion?

Introduction Question

- Before we go into specific fatigue questions, we'd just like to learn a little bit about your background – what brought you to this role?
- What does your job entail? How long have you been doing your current role?
- If I say 'fatigue', what do you think about?

What is the manager's view of the prevalence of fatigue/sleepiness among their bus drivers?

- To what extent do you believe fatigue/sleepiness is a problem in your industry?
- Have you ever experienced a driver reporting suffering from fatigue at work? If so, what happened and what did you do about it?
- What is the general culture around fatigue in your organisation?
- What do you/your company do to ensure that drivers are fit to work and not fatigued?

What do managers perceive to be the causes and consequences of fatigue/sleepiness in bus drivers?

- What issues do you think cause drivers to be fatigued at work? (PROMPT: Shift work, long hours, monotonous tasks, stress, threats/violence)
- If a driver is fatigued, how do you think this would influence their driving?
- To what extent do you think fatigue/sleepiness influences safety at work? What is your biggest safety concern relating to sleepy drivers?
- Do you think there is a link between fatigue and accidents?

What strategies are used to manage fatigue/sleepiness at work?

- What do you believe the company is doing well in the management of fatigue/sleepiness?
- What do you believe the company is doing poorly in the management of fatigue/sleepiness?

- What are drivers expected to do if they feel fatigued/sleepy while driving? Do you think they follow this?
- What would you do if one of your drivers reported that they were too tired to come into work?
- If a driver came to you with concerns about fatigue how would you handle this? In your experience would drivers be likely/unlikely to come to you with this type of issue?
- Does your company offer training and advice on how to handle fatigue? If so, what generally does it cover? And who is it aimed at? If not, do you think it should?
- Is fatigue considered as part of accident/incident investigation? If so what approach is taken?
- If an accident/incident investigation concluded that a driver was fatigued, what action would be taken and how would this be decided upon?

Shift patterns/overtime

- Are shift patterns fixed or does the company allow drivers to swap shifts? Do you think this has an effect on fatigue?
- What is the policy around overtime? How much extra does the company allow drivers to pick up? Do you think this has an effect on fatigue?
- Is there a difference between older and younger drivers and their requests for overtime?

Additional questions if there is time

- Does the operator impose any rules about commuting e.g. distance a driver is allowed to live from a garage or how they commute?
- Do you as a Manager have any concerns about drivers' commute times? Can this influence fatigue at work?
- What would happen if a driver was too fatigued to drive home?

Closing

- Any other comments/questions?
- Thanks

Appendix D: Bus driver survey

Questions about your work as a bus driver

1. **How long have you been working as a bus driver?**

_____

2. **Is bus driving your main job?**

☐ Yes, my only job

☐ Yes, but I also have another job

☐ No, I have another job

☐ Yes, my only paid employment but I am also studying

3. **Do you work as a bus driver full time, or part time?**

☐ Full time

☐ Part Time

4. **How many hours do you usually work during a week as a bus driver?**

_____

5. **What type of schedule/roster pattern do you have?**

☐ Fixed roster on dedicated routes

☐ Rotating roster on dedicated routes

☐ Spares (no dedicated route) on a fixed roster

☐ Spares (no dedicated route) on a rotating roster

☐ Other (please specify) _____

6. **In general, how satisfied are you with your work schedule?**

☐ Very satisfied

☐ Quite satisfied

☐ Neither satisfied nor unsatisfied

☐ Quite unsatisfied

☐ Very unsatisfied

7. Does your work schedule as a bus driver include any of the following at least once (or more) each month?

				How big a problem is this for you? *1=very small 5=very big*				
	No	*Yes*		*1*	*2*	*3*	*4*	*5*
a) Morning shift (shift that starts at 06:00 or earlier)	☐	☐	*If yes:*	☐	☐	☐	☐	☐
b) Daytime shift (shift between 07:00 - 19:00)	☐	☐	*If yes:*	☐	☐	☐	☐	☐
c) Evening shift (shift between 19:00 - 00:00)	☐	☐	*If yes:*	☐	☐	☐	☐	☐
d) Night shift (at least 4 hours between 00:00 - 06:00)	☐	☐	*If yes:*	☐	☐	☐	☐	☐
e) A rota which includes both shifts in the daytime and the evening	☐	☐	*If yes:*	☐	☐	☐	☐	☐
f) Spreadovers (more than 1.5 hours break between shifts)	☐	☐	*If yes:*	☐	☐	☐	☐	☐
g) Less than 11 hours break between shifts	☐	☐	*If yes:*	☐	☐	☐	☐	☐
h) 6 or more working days without rest	☐	☐	*If yes:*	☐	☐	☐	☐	☐
i) More than 10 hours overtime per week (paid or unpaid)	☐	☐	*If yes:*	☐	☐	☐	☐	☐
j) Short notice of the shift you are expected to work (less than 1 week)	☐	☐	*If yes:*	☐	☐	☐	☐	☐
k) Variability in shift start times (e.g. starting at 9am one day, then 11am the next)	☐	☐	*If yes:*	☐	☐	☐	☐	☐
l) Bus routes running longer than they usually would due to unforeseen circumstances (e.g. traffic)	☐	☐	*If yes:*	☐	☐	☐	☐	☐

8. Please answer the following questions about your working hours as a bus driver.								
				How big a problem is this for you? 1= very small…5=very big				
	No	*Yes*		*1*	*2*	*3*	*4*	*5*
a) Do you think your working hours cause your sleep to be disturbed?	☐	☐	*If yes:*	☐	☐	☐	☐	☐
b) Do you think your working hours contribute to sleepiness when you are driving the bus?	☐	☐	*If yes:*	☐	☐	☐	☐	☐
c) Do you think your working hours are associated with any health risks?	☐	☐	*If yes:*	☐	☐	☐	☐	☐
d) Do you think your working hours are associated with an accident risk?	☐	☐	*If yes:*	☐	☐	☐	☐	☐
e) Do you think sleepiness in your work increases the risk of serious mistakes?	☐	☐	*If yes:*	☐	☐	☐	☐	☐
f) Would you say your working hours cause fatigue when driving the bus?	☐	☐	*If yes:*	☐	☐	☐	☐	☐

9. Please answer the following questions about your working hours as a bus driver.								
				How big a problem is this for you? 1= very small…5=very big				
	No	*Yes*		*1*	*2*	*3*	*4*	*5*
a) Do you think it is easy to influence your working hours?	☐	☐	*If no:*	☐	☐	☐	☐	☐
b) Do your working hours allow you to have a good work/ life balance?	☐	☐	*If no:*	☐	☐	☐	☐	☐
c) Do you think you get enough breaks at work?	☐	☐	*If no:*	☐	☐	☐	☐	☐

10. Are you able to swap shifts with other drivers?

☐ No

☐ Yes, with employer permission

☐ Yes, either with or without employer permission

a. If so, how often does this occur?

☐ Every month

☐ Every 2-3 months

☐ Every 4-6 months

☐ Once or twice a year

11. Thinking about your commute, which of the following do you use to get to work?

☐ Walk ☐ Car ☐ Train

☐ Bus ☐ Underground ☐ Cycle

☐ Other (please specify) _____

a. During your commute, how long does it take you to get to work from home?

_____

Questions about your sleep

12. In general, how would you rate your sleep in the last 3 months?

☐ Very good

☐ Quite good

☐ Neither good nor bad

☐ Quite bad

☐ Very bad

13. Have you ever been diagnosed with a disorder or condition which affects your sleep, e.g. obstructive sleep apnoea?

☐ Yes

☐ No

a. If yes, which condition or disorder?

_____

b. Have you declared this to your employer?

☐ Yes

☐ No

14. Please indicate the degree to which the following have happened to you during the last 3 months.

	Never	**Seldom** *(One or few times a year)*	**Sometimes** *(Several times a month)*	**Often** *(1-2 times a week)*	**Most often** *(3-4 times a week)*	**Always** *(5 times or more a week)*
a) Difficulty in falling asleep	☐	☐	☐	☐	☐	☐
b) Difficulty in waking up	☐	☐	☐	☐	☐	☐
c) Repeated waking up during the night with problems falling asleep again	☐	☐	☐	☐	☐	☐
d) Severe snoring (own)	☐	☐	☐	☐	☐	☐
e) Difficulty catching your breath during sleep	☐	☐	☐	☐	☐	☐
f) Interrupted breathing during sleep (sleep apnoea)	☐	☐	☐	☐	☐	☐
g) Nightmares	☐	☐	☐	☐	☐	☐
h) Not feeling rested upon waking up	☐	☐	☐	☐	☐	☐
i) Waking up too early	☐	☐	☐	☐	☐	☐
j) Disturbed or worried sleep	☐	☐	☐	☐	☐	☐
k) Involuntary tremors in the legs that interfere with sleep	☐	☐	☐	☐	☐	☐
l) Overly light sleep	☐	☐	☐	☐	☐	☐
m) Being constantly tired throughout the day	☐	☐	☐	☐	☐	☐
n) Physical tiredness	☐	☐	☐	☐	☐	☐
o) Mental fatigue	☐	☐	☐	☐	☐	☐
p) Feeling sleepy at work	☐	☐	☐	☐	☐	☐
q) Feeling sleepy during leisure time	☐	☐	☐	☐	☐	☐
r) Involuntary falling asleep (e.g. microsleep) at work	☐	☐	☐	☐	☐	☐
s) Involuntary falling asleep (e.g. microsleep) during leisure time	☐	☐	☐	☐	☐	☐
t) The need to fight to stay awake during daytime	☐	☐	☐	☐	☐	☐

15. How much sleep do you ideally need between shifts to be able to drive safely/ feel rested?

_____

16. How much sleep do you usually get between shifts?

_____

17. How often do you take a nap (a short sleep during the day)?

☐ Almost never

☐ A few times a month

☐ Once a week

☐ A few times a week

☐ Every day/ almost always

a. If you nap, on average how long do you nap for?

_____

18. How many cups of coffee do you drink on average in a work day? (e.g. 0, 1, 2 etc.)

_____

19. How many cans of energy drink (e.g. redbull, monster) do you drink on average in a work day? (e.g. 0, 1, 2 etc.)

_____

20. Do you ever take caffeine tablets (e.g. ProPlus) on a work day?

☐ Never

☐ A few times a month

☐ At least once a week

☐ A few times a week

☐ Everyday/ almost always

Questions about your health

21. In general, how would you rate your health?

☐ Very good

☐ Quite good

☐ Neither good nor bad

☐ Quite bad

☐ Very bad

22. On a scale from 1-10, where 1 is the lowest level, and 10 is the highest, how stressed would you rate yourself over the last 3 months?

1 2 3 4 5 6 7 8 9 10

23. Are you a smoker?

☐ Non-smoker, never been a smoker, only smoked a few times

☐ Non-smoker, but previously have been a smoker (not for the last 6 months or more)

☐ Smoker

☐ E-cigarette user

24. How often do you exercise in your leisure time?

☐ Almost never, mostly inactive, occasional walks

☐ Seldom or irregular exercise, cycle or walk sometimes

☐ Regular, low impact exercise, cycle to work, walk often

☐ Regular, high impact exercise, at least twice per week, (sweating to a high degree)

☐ Competitive exercise, training or competing

25. Do you take sleeping pills to help you sleep?

☐ No

☐ Yes, sometimes

☐ Yes, on a regular basis

26. Please read each statement and answer corresponding to how you have been feeling on average during the last 3 months

	Not at all	Sometimes	Quite often	Almost always
a) There are some days when I feel hyper all the time	☐	☐	☐	☐
b) There are days when I feel very stressed, at the limit of what I can handle	☐	☐	☐	☐
c) I have difficulties relaxing during leisure time	☐	☐	☐	☐
d) I am often tense	☐	☐	☐	☐
e) I often feel worried	☐	☐	☐	☐
f) I am often restless	☐	☐	☐	☐
g) I do not feel rested after being at home and resting for a couple of days	☐	☐	☐	☐
h) I have days when I feel stressed all the time	☐	☐	☐	☐

Questions relating to yourself as a bus driver

27. How much enjoyment do you get from bus driving? Please indicate on the scale below where 1 is no enjoyment (driving is for income only), and 10 is high enjoyment (driving is fun)

1 2 3 4 5 6 7 8 9 10

28. On a scale from 1-10, where 1 is the lowest level, and 10 is the highest, how stressed do you feel daily while driving the bus?

1 2 3 4 5 6 7 8 9 10

29. How often do you have to fight sleepiness in order to stay awake while driving the bus?

☐ Never

☐ Occasionally

☐ 2-4 times a month

☐ 2-3 times a week

☐ 4 or more times a week

30. In the past 12 months, have you had to stop the bus due to fatigue?

☐ Never

☐ Once

☐ Twice

☐ Three times

☐ More than three times

31. In the past 12 months, have you wanted to stop the bus due to fatigue, but been unable to?

☐ Never

☐ Once

☐ Twice

☐ Three times

☐ More than three times

32. In the past 12 months, have you fallen asleep whilst driving the bus?

☐ Never

☐ Once

☐ Twice

☐ Three times

☐ More than three times

33. In the past 12 months have you have a 'close call' on the road while driving the bus because you were sleepy?

☐ Never

☐ Once

☐ Twice

☐ Three times

☐ More than three times

a. Do you think your employer knows that this close call was because you were sleepy?

☐ Yes

☐ No

34. In the past 12 months, have you had a road crash while driving the bus because you were sleepy?

☐ Never

☐ Once

☐ Twice

☐ Three times

☐ More than three times

a. Do you think your employer knows that this crash was because you were sleepy?

☐ Yes

☐ No

35. In the last 10 years have you experienced an incident or crash where sleepiness was partly or solely to blame? This could be whilst driving the bus, or whilst driving your own vehicle.

☐ No

☐ Yes, once

☐ Yes, several times

☐ Do not remember

36. In the past 12 months when driving the bus, have you ever experienced any of these symptoms? Select all that apply

☐ Yawning

☐ Frequent eye blinks

☐ Difficulty keeping eyes open

☐ Difficulty in concentrating on driving

☐ Needing to change position frequently

☐ Slower reactions to traffic events

☐ Increased variation in speed

☐ Dreamlike state of consciousness

☐ Head nodding

☐ Other (please specify) _____

37. What time of day are you most likely to feel sleepy whilst driving the bus? You can select more than one option.

☐ Early morning (04:00 – 08:00)

☐ Mid-morning (08:00 – 12:00)

☐ Afternoon (12:00 – 16:00)

☐ Early evening (16:00 – 20:00)

☐ Late evening (20:00 – 00:00)

☐ Night (00:00 – 04:00)

☐ I don't feel sleepy whilst driving the bus

38. At what point in your shift do you feel most sleepy whilst driving the bus? You can select more than one option.

☐ When you start driving

☐ Before a break

☐ After a break without food

☐ After a break with food/ lunch

☐ At the end of your shift

☐ Other (please specify) _____

☐ I don't feel sleepy whilst driving the bus

39. At what point in your shift rotation do you feel most sleepy when driving the bus? You can select more than one option.

☐ First day back after a rest day

☐ Two days back after a rest day

☐ Last day of work before a rest day

☐ The first day of a new type of shift (e.g. the first early after a late)

☐ Other (please specify) _____

☐ I don't feel sleepy whilst driving the bus

40. Do you do anything whilst driving the bus to reduce sleepiness and keep yourself alert? If so, what do you do? Select all that apply.

☐ Stopping for a break

☐ Opening a window

☐ Drinking caffeine

☐ Eating sweet or a sugary snack

☐ Chewing gum

☐ Singing/ talking to yourself

☐ Body movements whilst driving

☐ Exercise

☐ Music

☐ Turning on the fan or AC

☐ Driving slower

☐ Driving more actively

☐ Driving faster

☐ Make an excuse to stretch (e.g. check the mirrors or check the back safety window even though you know there is nothing wrong with it)

☐ Other (please specify) _____

☐ I do not use any techniques to reduce sleepiness

41. Do you do anything when you are not driving the bus to reduce sleepiness and keep yourself alert (e.g. during breaks, between shifts, at bus stops)? If so, what do you do? Select all that apply.

☐ Going for a short walk

☐ Opening a window

☐ Drinking caffeine

☐ Eating sweet or a sugary snack

☐ Chewing gum

☐ Singing/ talking to yourself

☐ Exercise

☐ Music

☐ Turning on the fan or AC

☐ Make an excuse to stretch (e.g. check the mirrors or check the back safety window even though you know there is nothing wrong with it)

☐ Other (please specify) _____

☐ I do not use any techniques to reduce sleepiness

42. How often do you have to actively do something to keep yourself alert when driving the bus?

☐ Never

☐ Occasionally

☐ 2-4 times a month

☐ 2-3 times a week

☐ 4 or more times a week

43. On a typical work day, do you bring your own food or buy something during the day?

☐ Bring my own food

☐ Buy something from my employers canteen

☐ Buy food from a shop or cafe

☐ I don't have food at work

a. If you eat a meal during your work day, which of the following would you usually eat?

☐ Packet food/ meal deal (e.g. a packet sandwich with a snack and a drink)

☐ A small hot meal (e.g. a jacket potato)

☐ A large hot meal (e.g. meat and vegetables)

44. Do you encounter any of these difficulties during your scheduled rest periods?

				How big a problem is this for you? 1=very small…5=very big				
	Yes	*No*		*1*	*2*	*3*	*4*	*5*
a) Nowhere to sit	☐	☐	*If yes:*	☐	☐	☐	☐	☐
b) Inability to access a toilet	☐	☐	*If yes:*	☐	☐	☐	☐	☐
c) Insufficient time to eat	☐	☐	*If yes:*	☐	☐	☐	☐	☐
d) Insufficient time to rest	☐	☐	*If yes:*	☐	☐	☐	☐	☐
e) Late running of the bus leading to a shorter break	☐	☐	*If yes:*	☐	☐	☐	☐	☐
f) No access to an indoor rest area	☐	☐	*If yes:*	☐	☐	☐	☐	☐

Background Questions

45. What is your age?

_____

46. What is your gender?

☐ Male ☐ Female ☐ Other ☐ Prefer not to say

47. What is your height?

_____

48. What is your weight?

_____

49. What is your current relationship status?

☐ Single

☐ Living with a partner

☐ Married/ Civil partnership

☐ Separated/ Divorced

☐ Widowed

☐ Prefer not to say

50. Do you have children who live with you at home?

☐ Yes

☐ No

a. If yes, please list current ages

_____

51. What is the postcode of your home address?

_____

52. What is your highest level of education?

☐ No schooling completed

☐ Secondary school

☐ Sixth form or college

☐ Trade/ technical/ vocational training

☐ Bachelor's degree

☐ Master's degree

☐ Doctorate degree

53. Which operator do you work for?

☐ Abellio

☐ Arriva

☐ Go Ahead

☐ HCT group

☐ Uno/ Herts Uni

☐ Metro line

☐ RATP Dev

☐ Stage coach buses

☐ Sullivans

☐ TowerTransit

54. If you have any further comments relating to any of the questions in this survey, or any further comments about fatigue in general, we would be happy to hear them.

Appendix E: On-road study background questionnaire

For the on-road study, the following questions from the bus driver survey (Appendix D) were used:

- Questions 1-9
- Questions 11- 13a
- Questions 14-17
- Questions 21-22
- Questions 24-25
- Question 27
- Questions 29 -32
- Question 34
- Questions 37-38
- Questions 45-48
- Question 52
- Question 54

In addition, two further questions were added (see below)

1. **One hears about "morning" and "evening" types of people. Which one of these types do you consider yourself to be?**

☐ Definitely a morning type

☐ Rather more a morning than an evening type

☐ Neither a morning type nor an evening type

☐ Rather more an evening than a morning type

☐ Definitely an evening type

2. **How much sleep do you ideally need each night to feel rested?**

_____

Appendix F: After drive questionnaire used in the on-road study

Please answer the following questions about your experience

1. How difficult did you find it to stay awake while driving?

Not at all difficult						Very difficult
1	2	3	4	5	6	7
☐	☐	☐	☐	☐	☐	☐

2. How stressed did you feel while driving?

Not at all stressed						Very stressed
1	2	3	4	5	6	7
☐	☐	☐	☐	☐	☐	☐

3. Did you feel worried while driving?

Not at all worried						Very worried
1	2	3	4	5	6	7
☐	☐	☐	☐	☐	☐	☐

If you marked 5 or higher on any of the questions above, please describe the reason?

_____

_____

_____

_____

_____

4. How similar was this drive compared to an everyday drive on the same route?

Not at all similar						Very similar
1	2	3	4	5	6	7
☐	☐	☐	☐	☐	☐	☐

	Yes	No	Don't know
5. Did you lose control of the vehicle at any time during the drive?	☐	☐	☐
6. Did you lose awareness of the surrounding traffic at any time of the drive?	☐	☐	☐
7. Did you experience sleepiness at any time of the drive?	☐	☐	☐
8. Did you use any countermeasure to stay awake while driving? **If yes,** what did you do to stay awake? _____ _____ _____	☐	☐	☐

9. Was there any experience or situation today that influenced you're driving and made the drive more demanding?

	No influence	Some influence	Moderate influence	Large influence	Very large influence
Stressed, because _____ _____	☐	☐	☐	☐	☐
Sleepy, because _____ _____	☐	☐	☐	☐	☐
Inattentive, because_____ _____	☐	☐	☐	☐	☐
Other, because_____ _____	☐	☐	☐	☐	☐

10. Did anything influence your wellbeing in a negative way today? (for example headache, pain in the stomach etc.)

☐**Yes** ☐**No**

If yes, what was the main reason?

_____

Appendix G: On-road technical appendix

Physiological measurements

Physiological data were collected using a Vitaport 3 system. Electrodes for electrooculography (EOG) to record and detect blinks, and electrocardiography (ECG) to record electrical activity of the heart were placed on the face and on the body (see Figure 2.2 in the main body of the text). The electrodes were placed mainly on the right side of the face, which was facing away from the passengers. Heartbeats (R-peaks) were extracted from the ECG signal and the resulting R-R time series was used to derive several heart rate variability (HRV) metrics (Shaffer & Ginsberg, 2017; Laborde, Mosley & Thayer, 2017). The main idea is that stress will increase the heart rate and reduce the heart rate variability, whereas sleepiness and fatigue will reduce the heart rate and increase the heart rate variability. In this study, the HRV metric root mean square of successive R-R differences (RMSSD) will be reported. The blink parameters were extracted from the vertical EOG signal with an automatic blink detection algorithm (Jammes, Sharabty & Esteve, 2008). Four blink duration-based parameters were calculated; the mean, standard deviation and 95th percentile blink duration, and the percentage of eye blinks with a duration longer than 0.150 seconds (Fors et al., 2011).
For the analysis all physiological parameters were calculated in five-minute intervals for each drive to mirror the fact that KSS and SUS were reported every five minutes.

Statistical analysis

Results from the sleep and wake diaries were compared between rest days, morning shifts and daytime shifts using GLM ANOVA and Chi-square tests. Differences in sleep patterns, measured with actigraphy, before the morning and daytime drive were analysed with paired samples t-tests.

The data gathered from the on-road study was unbalanced in terms of time driven during morning shifts compared to daytime shifts. The morning drives were on average shorter than the daytime drives. To achieve a balanced data, data from minute 1 to minute 49 of each drive was included in the analysis, which corresponded to the time driven during the fastest morning drives. The purpose of this was to allow direct statistical comparisons between the early morning and daytime drives. In cases where the daytime drives lasted longer than 49 minutes, it would not be possible to compare them to an early morning drive.

Driver physiology and driver behaviour during the driving were analysed with a GLM ANOVA considering three types of comparison. The two conditions were compared (Morning/ Day); within each drive the time into the analysis period was considered as time on task (5-10-15-20-25-30-35-40-45 minute) and the direction of travel toward city centre (yes/no). The reason for the latter was the effect of traffic density in different regions of the route. Participant was used as a random factor. The considered variables were: Sleepiness, Stress, Blink duration, Heart rate variability (HRV RMSSD), Percentage of long blink durations (>0.15 s), Speed (mph), Accelerations and Decelerations (m/s^2). The model included both main effects and 2-way interactions.

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Appendix H: Bus operator background questionnaire.

Bus operator background information questionnaire

The purpose of this questionnaire is to gather background information from bus operators in London. The questions relate to central company policy and governance. In subsequent stages of the work local level managers and drivers will be consulted.

Answers to these questions will help inform the work undertaken by Loughborough University and VTI about bus driver fatigue under contract for TfL. Information in all reports provided to TfL will be anonymous. If you have any questions about this work please contact Dr Ashleigh Filtness A.J.Filtness@lboro.ac.uk

Questions	Space for your answers
Operator company name	
Job tile/role of person completing this questionnaire	

All questions relate to bus operations in London only.

Questions about your drivers	
1. How many bus drivers do you employ?	
2. What is the average length of time bus drivers have been employed?	
3. Approximately what proportion of your drivers are not native English speakers?	
4. Is there any prevalent language (other than English) spoken amongst your bus drivers to which you would recommend we translate written materials to when contacting drivers?	
5. What proportion of your bus drivers are female?	
6. Are drivers subject to medical fitness tests, if so how regularly?	
7. Do drivers have a fixed base, or do they work out of a range of garages/ depots?	
8. How are drivers paid (e.g. day rate, annual salary)? If mixed, what proportion of drivers are salaried vs casual?	
9. Is there an organisation requirement for drivers to confirm fitness to drive at the start (or during) a shift? Is so what does this include?	
Questions about your busses	
10. How many buses are in your London fleet?	
11. What make/model of buses do you operate?	
12. How many garages/depots do you have in London?	

Questions about your organisation operations	
13. What hours of the day do your buses operate? (are operations 24h?)	
14. If night time driving is required, what daytime hours does your organisation define as being night shift?	
15. Are drivers offered financial incentive to work nights?	
16. What type of shifts do drivers in your organisation work, i.e. day shifts only, night shifts only, split shifts, or mixed work?	
17. How are shift schedules planned?	
18. How are drivers allocated shifts (are drivers permitted to select their own preferred shifts)?	
19. At what level is responsibility for compliance with Hours of Work Rules held? E.g. driver, local manager, shift scheduler etc	
20. Is there a formal company policy or training given to drivers on what to do if they feel unwell while driving the bus? If so what is this? (or would this be handled at individual manager level?)	
21. Is there any formal fatigue management content in your driver training program?	
22. Does your crash/incident reporting/recording/investigation system include consideration of driver fatigue?	

Appendix I: Complete results obtained in the bus driver survey.

Questions about your work as a bus driver

1. **How long have you been working as a bus driver?**

2 months – 43 years (M = 10.52 years, SD = 8.47 years)

2. **Is bus driving your main job?**

☐ Yes, my only job – 97%
☐ Yes, but I also have another job – 0.5%
☐ No, I have another job – 0.3%
☐ Yes, my only paid employment but I am also studying – 0.8%

3. **Do you work as a bus driver full time, or part time?**

☐ Full time – 95.7% ☐Part Time – 2.7%

4. **How many hours do you usually work during a week as a bus driver?**

8 – 75 hours (M = 44.35, SD = 8.21)

5. **What type of schedule/roster pattern do you have?**

☐ Fixed roster on dedicated routes – 37.5%
☐ Rotating roster on dedicated routes – 42.9%
☐ Spares (no dedicated route) on a fixed roster – 8.1%r
☐ Spares (no dedicated route) on a rotating roster - 9.3%
☐ Other (please specify) - 1.8%

6. **In general, how satisfied are you with your work schedule?**

☐ Very satisfied – 7%
☐ Quite satisfied – 21.5%
☐ Neither satisfied nor unsatisfied 25.1%
☐ Quite unsatisfied – 24.4%
☐ Very unsatisfied – 21.7%

7. **Does your work schedule as a bus driver include any of the following at least once (or more) each month?**

				How big a problem is this for you? 1=very small 5=very big				
	No	**Yes**		**1**	**2**	**3**	**4**	**5**
Morning shift (shift that starts at 06:00 or earlier)	13.7%	80.7%	If yes:	32.1%	14.7%	19.8%	11%	14.8%
Daytime shift (shift between 07:00 - 19:00)	11.6%	79.8%	If yes:	34.2%	17.3%	21.1%	8%	10.5%
Evening shift (shift between 19:00 - 00:00)	21.5%	67.8%	If yes:	22.9%	14%	18.2%	11.8%	23.3%
Night shift (at least 4 hours between 00:00 - 06:00)	67.4%	18.6%	If yes:	22.2%	9.1%	11.9%	11.1%	31.3%
A rota which includes both shifts in the daytime and the evening	25.9%	62.9%	If yes:	10.5%	12.6%	21.5%	14.7%	29.3%

Spreadovers (more than 1.5 hours break between shifts)	26.8%	62.7%	If yes:	19.1%	12%	17.1%	10.7%	30.9%
Less than 11 hours break between shifts	39.6%	48.5%	If yes:	9.3%	7.3%	12.5%	14.9%	45.3%
6 or more working days without rest	13.5%	78.1%	If yes:	9.6%	7.9%	12.1%	15.6%	43.2%
More than 10 hours overtime per week (paid or unpaid)	50.6%	37.6%	If yes:	21.2%	14.3%	19.6%	9%	22.2%
Short notice of the shift you are expected to work (less than 1 week)	56.7%	32.5%	If yes:	11.1%	11.1%	13.9%	13.2%	35.7%
Variability in shift start times (e.g. starting at 9am one day, then 11am the next)	21.5%	68.8%	If yes:	7.3%	10.2%	16.9%	18.4%	36.7%
Bus routes running longer than they usually would due to unforeseen circumstances (e.g. traffic)	9.3%	82.3%	If yes:	8.8%	11.7%	17.3%	15.1%	37.8%

8. Please answer the following questions about your working hours as a bus driver.

				How big a problem is this for you? 1= very small…5=very big				
	No	**Yes**		**1**	**2**	**3**	**4**	**5**
Do you think your working hours cause your sleep to be disturbed?	13.9%	83.3%	If yes:	1.8%	4.4%	12.8%	18.8%	56.4%
Do you think your working hours contribute to sleepiness when you are driving the bus?	17.1%	78.8%	If yes:	3.3%	7.9%	14.6%	16.4%	51.7%
Do you think your working hours are associated with any health risks?	14.3%	81.5%	If yes:	2.6%	4.4%	15.6%	18.5%	52.7%
Do you think your working hours are associated with an accident risk?	16.1%	79.2%	If yes:	3.5%	7.4%	14%	17.7%	51.3%
Do you think sleepiness in your work increases the risk of serious mistakes?	7%	88.8%	If yes:	3.7%	4.7%	10.8%	15.6%	58.3%
Would you say your working house cause fatigue when driving the bus?	11.5%	84.4%	If yes:	3.1%	6%	15.1%	16.5%	52.9%

9. Please answer the following questions about your working hours as a bus driver.

				How big a problem is this for you? 1= very small…5=very big				
	No	**Yes**		**1**	**2**	**3**	**4**	**5**
Do you think it is easy to influence your working hours?	67.2%	29.3%	If no:	4.7%	5.1%	18.8%	15.7%	33.7%
Do your working hours allow you to have a good work/ life balance?	80.2%	17.7%	If no:	1.4%	2.4%	8.4%	15.2%	53.6%
Do you think you get enough breaks at work?	64.7%	33.2%	If no:	2.4%	4.6%	14.4%	16.2%	44.5%

10. Are you able to swap shifts with other drivers?

☐ No – 7.5%

☐ Yes, with employer permission – 63.9%

☐ Yes, either with or without employer permission – 27.9%

a. If so, how often does this occur?

☐ Every month – 36.8%
☐ Every 2-3 months – 19.5%
☐ Every 4-6 months – 7.7%
☐ Once or twice a year – 25.6%

11. Thinking about your commute, which of the following do you use to get to work?

☐ Walk – 24.5% ☐ Car – 62.5% ☐ Train – 8.4%
☐ Bus – 37.2% ☐ Underground – 12% ☐ Cycle – 10.6%
☐ Other – 6.7%

a. During your commute, how long does it take you to get to work from home?

5 – 210 minutes (M = 39.49 minutes, SD = 25.11 minutes)

Questions about your sleep

12. In general, how would you rate your sleep in the last 3 months?

☐ Very good – 4.8%
☐ Quite good – 13.3%
☐ Neither good nor bad – 35%
☐ Quite bad – 34.6%
☐ Very bad - 11.9 %

13. Have you ever been diagnosed with a disorder or condition which affects your sleep, e.g. obstructive sleep apnoea?

☐ Yes – 4.4%
☐ No – 95.1%

a. Have you declared this to your employer?

☐ Yes – 69.5%
☐ No – 30.5%

14. Please indicate the degree to which the following have happened to you during the last 3 months.

	Never	Seldom *(One or few times a year)*	Sometimes *(Several times a month)*	Often *(1-2 times a week)*	Most often *(3-4 times a week)*	Always *(5 times or more a week)*
Difficulty in falling asleep	17.7%	15.4%	23.7%	15.3%	17.1%	8.3%
Difficulty in waking up	24.2%	19.7%	19.1%	13.1%	11.5%	9.7%
Repeated waking up during the night with problems falling asleep again	14.7%	17.2%	21.3%	14.8%	15%	14.3%
Severe snoring (own)	31.3%	15.9%	14.2%	8.5%	8.1%	18.3%

Difficulty catching your breath during sleep	70.6%	11.1%	5.6%	2.7%	2.2%	3.8%
Interrupted breathing during sleep (sleep apnoea)	78.2%	7.2%	4.2%	1.9%	1.5%	2.9%
Nightmares	44.5%	25.6%	13.1%	6.8%	3.0%	3.4%
Not feeling rested upon waking up	9.5%	14.9%	21.9%	17.4%	16%	17.8%
Waking up too early	11.5%	15.6%	23.7%	17.5%	14.3%	14.6%
Disturbed or worried sleep	17.4%	19.2%	20.3%	15.4%	11.2%	13.4%
Involuntary tremors in the legs that interfere with sleep	61.3%	13%	8.7%	5.1%	3.5%	4.9%
Overly light sleep	31.2%	20.6%	19.4%	10.4%	5.6%	8.8%
Being constantly tired throughout the day	12.5%	18.7%	22%	15.4%	12.3%	16.3%
Physical tiredness	12.9%	20%	22.5%	14.3%	12.7%	14.9%
Mental fatigue	14.3%	16.9%	19.3%	15%	13%	17.7%
Feeling sleepy at work	12.4%	18.5%	21.4%	18.6%	13.2%	13.2%
Feeling sleepy during leisure time	14.4%	17.8%	23.9%	16.4%	12.2%	11.8%
Involuntary falling asleep (e.g. microsleep) at work	50.7%	17%	12.2%	6.2%	4.9%	5.8%
Involuntary falling asleep (e.g. microsleep) during leisure time	40%	19.2%	13.8%	10.5%	6.7%	6.2%
The need to fight to stay awake during daytime	24.9%	22.5%	19.6%	10.5%	10.1%	10.1%

Sleep quality index – Range 1-6 (M = 3.35, SD = 1.36)
Sleepiness index – Range 1-6 (M = 2.83, SD = 1.31)
Fatigue index – Range 1-6 (M = 3.45, SD = 1.53)
Impaired Waking index – Range 1-6 (M = 3.34, SD = 1.45)
Suspected sleep apnea index – Range 1-6 (M = 2.03, SD = 1.18)

15. How much sleep do you ideally need between shifts to be able to drive safely/ feel rested?
Range = 5 – 11 hours (*M* = 7h, 55m, *SD* = 1h 8m).
NB. Answers from 10 participants were extreme outliers and have been excluded.

16. How much sleep do you usually get between shifts?
Range = 4 – 12 hours (*M* = 6h 30m, *SD* = 1h 20m)
NB. Answers from 13 participants were extreme outliers and have been excluded.

17. How often do you take a nap (a short sleep during the day)?

☐ Almost never – 44.3%
☐ A few times a month – 22.5%
☐ Once a week – 7.1%
☐ A few times a week – 17.5%
☐ Every day/ almost always – 7.8%

a. If you nap, on average how long do you nap for?
5-295 minutes (M = 61.80 minutes, SD = 45.74 minutes)

18. How many cups of coffee do you drink on average in a work day? (e.g. 0, 1, 2 etc.)
0 – 20 cups (M = 3.36, SD = 2.45)

19. How many cans of energy drink (e.g. redbull, monster) do you drink on average in a work day? (e.g. 0, 1, 2 etc.)
0 – 11 cans (M = 0.51, SD = 1.17)

20. Do you ever take caffeine tablets (e.g. ProPlus) on a work day?

☐ Never – 89.5%
☐ A few times a month – 6.4%
☐ At least once a week – 1.4%
☐ A few times a week – 1.6%
☐ Everyday/ almost always – 0.9%

Questions about your health

21. In general, how would you rate your health?

☐ Very good – 15.5%
☐ Quite good – 43.9%
☐ Neither good nor bad – 30.4%
☐ Quite bad – 9%
☐ Very bad 0.9%

22. On a scale from 1-10, where 1 is the lowest level, and 10 is the highest, how stressed would you rate yourself over the last 3 months?
Range 1- 10, mode = 8 (M = 5.67, SD = 2.81)

23. Are you a smoker?

☐ Non-smoker, never been a smoker, only smoked a few times – 49.4%
☐ Non-smoker, but previously have been a smoker – 22.8%
☐ Smoker – 22.2%
☐ E-cigarette user – 4.7%

24. How often do you exercise in your leisure time?

☐ Almost never, mostly inactive, occasional walks – 31.8%
☐ Seldom or irregular exercise, cycle or walk sometimes – 33.6%
☐ Regular, low impact exercise, cycle to work, walk often – 23.1%
☐ Regular, high impact exercise, at least twice per week – 9.4%
☐ Competitive exercise, training or competing – 1.6%

25. Do you take sleeping pills to help you sleep?

☐ No – 91.9%
☐ Yes, sometimes – 6.7%
☐ Yes, on a regular basis – 1%

26. Please read each statement and answer corresponding to how you have been feeling on average during the last 3 months

	Not at all	Sometimes	Quite often	Almost always
There are some days when I feel hyper all the time	60.4%	30.2%	6.4%	1.6%
There are days when I feel very stressed, at the limit of what I can handle	22.4%	42.4%	25.2%	9%
I have difficulties relaxing during leisure time	29.2%	39.5%	20.3%	9.8%
I am often tense	23.8%	39%	25.7%	10%
I often feel worried	19.4%	40.1%	27%	11.8%
I am often restless	20.8%	42.1%	24.5%	10.4%
I do not feel rested after being at home and resting for a couple of days	24.2%	34.4%	23.1%	16.8%
I have days when I feel stressed all the time	27%	36.1%	21.4%	13.7%

Questions relating to yourself as a bus driver

27. How much enjoyment do you get from bus driving? Please indicate on the scale below where 1 is no enjoyment (driving is for income only), and 10 is high enjoyment (driving is fun)

Range 1-10, mode = 1 (M = 4.95, SD = 3.01)

28. On a scale from 1-10, where 1 is the lowest level, and 10 is the highest, how stressed do you feel daily while driving the bus?

Range 1-10, mode = 3 (M = 5.45, SD = 2.79)

29. How often do you have to fight sleepiness in order to stay awake while driving the bus?

☐ Never – 21.4%
☐ Occasionally – 42.1%
☐ 2-4 times a month – 15.5%
☐ 2-3 times a week – 13.5%
☐ 4 or more times a week - 7.2%

30. In the past 12 months, have you had to stop the bus due to fatigue?

☐ Never – 76.9%
☐ Once – 8.9%
☐ Twice – 5.8%
☐ Three times – 1.3%
☐ More than three times – 6.6%

31. In the past 12 months, have you wanted to stop the bus due to fatigue, but been unable to?

☐ Never – 44.3%
☐ Once – 12.4%

- ☐ Twice – 11.4%
- ☐ Three times – 3.6%
- ☐ More than three times – 28.1%

32. In the past 12 months, have you fallen asleep whilst driving the bus?

- ☐ Never – 82.7%
- ☐ Once – 6.1%
- ☐ Twice – 2.7%
- ☐ Three times – 1.8%
- ☐ More than three times 6.1%

33. In the past 12 months have you have a 'close call' on the road while driving the bus because you were sleepy?

- ☐ Never – 63.3%
- ☐ Once – 15.7%
- ☐ Twice – 8.7%
- ☐ Three times – 2.6%
- ☐ More than three times – 9.5%

a. Do you think your employer knows that this close call was because you were sleepy?

- ☐ Yes – 11.7%
- ☐ No- 87.9%

34. In the past 12 months, have you had a road crash while driving the bus because you were sleepy?

- ☐ Never – 94.1%
- ☐ Once- 4.6%
- ☐ Twice – 0.7%
- ☐ Three times – 0.1%
- ☐ More than three times - 0.1%

a. Do you think your employer knows that this crash was because you were sleepy?

- ☐ Yes – 23%
- ☐ No – 77%

35. In the last 10 years have you experienced an incident or crash where sleepiness was partly or solely to blame? This could be whilst driving the bus, or whilst driving your own vehicle.

- ☐ No – 79.5%
- ☐ Yes, once – 13.1%
- ☐ Yes, several times – 3.7%
- ☐ Do not remember 3.2%

36. In the past 12 months when driving the bus, have you ever experienced any of these symptoms? Select all that apply

- ☐ Yawning – 88.7%
- ☐ Frequent eye blinks – 52.8%
- ☐ Difficulty keeping eyes open – 44.5%
- ☐ Difficulty in concentrating on driving – 40.6%

- ☐ Needing to change position frequently – 54.5%
- ☐ Slower reactions to traffic events – 33.4%
- ☐ Increased variation in speed – 15.7%
- ☐ Dreamlike state of consciousness – 35.3%
- ☐ Head nodding – 22.5%
- ☐ Other – 1.8%

37. What time of day are you most likely to feel sleepy whilst driving the bus? You can select more than one option.

- ☐ Early morning (04:00 – 08:00) – 42.1%
- ☐ Mid-morning (08:00 – 12:00) – 24.3%
- ☐ Afternoon (12:00 – 16:00) – 24.7%
- ☐ Early evening (16:00 – 20:00) – 14.6%
- ☐ Late evening (20:00 – 00:00) – 35.3%
- ☐ Night (00:00 – 04:00) – 29.1%
- ☐ I don't feel sleepy whilst driving the bus – 11.6%

38. At what point in your shift do you feel most sleepy whilst driving the bus? You can select more than one option.

- ☐ When you start driving – 17.2%
- ☐ Before a break – 28.9%
- ☐ After a break without food – 13.3%
- ☐ After a break with food/ lunch – 42.8%
- ☐ At the end of your shift – 38.1%
- ☐ Other – 4.1%
- ☐ I don't feel sleepy whilst driving the bus – 14.1%

39. At what point in your shift rotation do you feel most sleepy when driving the bus? You can select more than one option.

- ☐ First day back after a rest day – 28.3%
- ☐ Two days back after a rest day – 16.6%
- ☐ Last day of work before a rest day – 45.3%
- ☐ The first day of a new type of shift (e.g. the first early after a late) – 47.4%
- ☐ Other – 3.3%
- ☐ I don't feel sleepy whilst driving the bus – 14%

40. Do you do anything whilst driving the bus to reduce sleepiness and keep yourself alert? If so, what do you do? Select all that apply.

- ☐ Stopping for a break – 8.8%
- ☐ Opening a window – 85.9%
- ☐ Drinking caffeine – 34.2%
- ☐ Eating sweet or a sugary snack – 32.7%
- ☐ Chewing gum – 31.1%
- ☐ Singing/ talking to yourself – 35.2%
- ☐ Body movements whilst driving – 40.3%
- ☐ Exercise – 7.5%
- ☐ Music – 1.6%
- ☐ Turning on the fan or AC – 25.5%
- ☐ Driving slower – 17.2%

- ☐ Driving more actively – 12.1%
- ☐ Driving faster – 4.8%
- ☐ Make an excuse to stretch (e.g. check the mirrors or check the back safety window even though you know there is nothing wrong with it) – 29.4%
- ☐ Other – 3.9%
- ☐ I do not use any techniques to reduce sleepiness – 7.2%

41. Do you do anything when you are not driving the bus to reduce sleepiness and keep yourself alert (e.g. during breaks, between shifts, at bus stops)? If so, what do you do? Select all that apply.

- ☐ Going for a short walk – 46%
- ☐ Opening a window – 37.2%
- ☐ Drinking caffeine – 40.4%
- ☐ Eating sweet or a sugary snack – 21.3%
- ☐ Chewing gum – 16.1%
- ☐ Singing/ talking to yourself – 14.6%
- ☐ Exercise – 16.6%
- ☐ Music – 13.5%
- ☐ Turning on the fan or AC – 7.5%
- ☐ Make an excuse to stretch (e.g. check the mirrors or check the back safety window even though you know there is nothing wrong with it) – 16.3%
- ☐ Other - 5.9%
- ☐ I do not use any techniques to reduce sleepiness – 14.1%

42. How often do you have to actively do something to keep yourself alert when driving the bus?

- ☐ Never – 17.6%
- ☐ Occasionally – 44.3%
- ☐ 2-4 times a month – 12.4%
- ☐ 2-3 times a week – 14.1%
- ☐ 4 or more times a week – 10.9%

43. On a typical work day, do you bring your own food or buy something during the day?

- ☐ Bring my own food – 49.8%
- ☐ Buy something from my employers' canteen – 9.3%
- ☐ Buy food from a shop or café – 37%
- ☐ I don't have food at work – 3.5%

a. If you eat a meal during your work day, which of the following would you usually eat?

- ☐ Packet food/ meal deal (e.g. a packet sandwich with a snack and a drink) – 47.7%
- ☐ A small hot meal (e.g. a jacket potato) – 26.9%
- ☐ A large hot meal (e.g. meat and vegetables) – 18.6%

44. Do you encounter any of these difficulties during your scheduled rest periods?

				How big a problem is this for you? 1=very small…5=very big				
	Yes	*No*		*1*	*2*	*3*	*4*	*5*
Nowhere to sit	34.1%	59.5%	*If yes:*	4.1%	6.9%	16%	21.2%	43.5%
Inability to access a toilet	43.7%	50%	*If yes:*	1.9%	5.9%	12.4%	14.2%	55.5%
Insufficient time to eat	59.5%	33.9%	*If yes:*	3%	7.1%	17.6%	17.5%	43.4%
Insufficient time to rest	66.9%	26.3%	*If yes:*	2.7%	6%	18.1%	18.7%	42.9%
Late running of the bus leading to a shorter break	87.4%	9.8%	*If yes:*	4.1%	5.2%	13.3%	15.8%	49.7%
No access to an indoor rest area	37.4%	56%	*If yes:*	4.5%	5.3%	10.3%	11.9%	52.2%

Background Questions

45. What is your age?
Range 20 – 73 (M = 45.13, SD = 10.89)

46. What is your gender?
☐ Male – 85.7% ☐ Female – 10.6% ☐ Other – 0.2% ☐ Prefer not to say – 3.5%

47. What is your height? / 48. What is your weight?
BMI range 14.79 – 56.98 (M = 27.67, SD = 5.15)

49. What is your current relationship status?
☐ Single – 18.1%
☐ Living with a partner – 16.3%
☐ Married/ Civil partnership – 53.7%
☐ Separated/ Divorced – 5.8%
☐ Widowed – 0.3%
☐ Prefer not to say – 5%

50. Do you have children who live with you at home?
☐ Yes – 53.6%
☐ No – 45.4%

52. What is your highest level of education?
☐ No schooling completed – 4.1%
☐ Secondary school – 34.4%
☐ Sixth form or college – 26.4%
☐ Trade/ technical/ vocational training – 20.5%
☐ Bachelor's degree – 11.6%
☐ Master's degree – 1.6%
☐ Doctorate degree – 0.1%

Appendix J: Driver survey - univariate logistic regressions for having to fight to stay awake, and having a sleep related incident. OR = odds ratio, CI = confidence intervals, p = significance. Significant values are presented in bold.

	Have to fight sleepiness			Sleep related incident in the last 10 years		
Univariate variables	***OR***	***CI***	***p***	***OR***	***CI***	***p***
Sleep						
Sleep condition	**3.05**	**1.78-5.22**	**0.000**	1.42	0.75-2.69	0.28
Sleep quality	**2.06**	**1.83-2.31**	**0.000**	**1.45**	**1.30-1.61**	**0.000**
Sleepiness	**3.07**	**2.68-3.53**	**0.000**	**1.52**	**1.36-1.69**	**0.000**
Fatigue	**2.35**	**2.10-2.64**	**0.000**	**1.48**	**1.34-1.64**	**0.000**
Impaired waking	**2.38**	**2.12-2.68**	**0.000**	**1.43**	**1.29-1.59**	**0.000**
Sleep apnoea	**1.48**	**1.33-1.64**	**0.000**	**1.23**	**1.10-1.38**	**0.000**
Self-reported sleep quality: Bad (ref)						
Neutral	**0.11**	**0.06-0.20**	**0.000**	**0.30**	**0.19-0.50**	**0.000**
Good	**0.20**	**0.15-0.29**	**0.000**	**0.56**	**0.40-0.77**	**0.000**
Amount of sleep lost	**1.01**	**1.01-1.01**	**0.000**	**1.00**	**1.00-1.01**	**0.03**
Under sleeping: no (ref) vs yes	**3.09**	**2.10-4.55**	**0.000**	**2.05**	**1.40-3.00**	**0.000**
Snoring: no (ref) vs yes	**1.85**	**1.41-2.43**	**0.000**	**1.48**	**1.11-1.99**	**0.01**
Work						
Roster type: fixed (ref) vs rotating	1.15	0.88-1.50	0.30	**1.40**	**1.05-1.88**	**0.02**
Morning shift	1.35	0.90-2.03	0.15	1.38	0.88-2.16	0.17
Daytime shift	1.17	0.77-1.79	0.46	0.98	0.63-1.54	0.94
Evening shift	1.10	0.79-1.52	0.58	0.94	0.67-1.33	0.72
Night shift	0.88	0.62-1.24	0.46	0.84	0.57-1.24	0.38
Rota with day and evening shifts	1.29	0.94-1.77	0.11	1.27	0.90-1.78	0.17
Spreadover	1.15	0.85-1.57	0.36	1.27	0.90-1.78	0.17
Less than 11h break	**1.45**	**1.09-1.93**	**0.01**	1.15	0.85-1.56	0.38
6 or more days without rest	**1.82**	**1.16-2.84**	**0.01**	1.39	0.89-2.16	0.15
More than 10h overtime	1.13	0.86-1.50	0.39	1.18	0.87-1.60	0.28
Short notice of shifts	**1.62**	**1.22-2.14**	**0.001**	1.31	0.97-1.78	0.08
Variability in start times	**1.79**	**1.24-2.56**	**0.002**	**1.52**	**1.04-2.22**	**0.03**
Over running of routes	1.21	0.75-1.94	0.44	1.25	0.75-2.08	0.40
Enjoyment from bus driving	**0.84**	**0.80-0.88**	**0.000**	**0.88**	**0.83-0.92**	**0.000**
Stress from bus driving	**1.28**	**1.21-1.34**	**0.000**	**1.17**	**1.11-1.23**	**0.000**
Driving a car to work	1.04	0.79-1.36	0.78	1.02	0.76-1.37	0.89
Commuting using public transport	**0.74**	**0.57-0.98**	**0.03**	1.10	0.83-1.47	0.51
Commute time	**1.01**	**1.00-1.01**	**0.02**	1.00	1.00-1.01	0.10
Nowhere to sit during breaks	**1.65**	**1.26-2.17**	**0.000**	1.28	0.95-1.73	0.11
Insufficient time to eat during breaks	**1.98**	**1.46-2.69**	**0.000**	**1.42**	**1.03-1.96**	**0.03**
Insufficient time to rest during breaks	**2.68**	**1.86-3.86**	**0.000**	**2.44**	**1.65-3.63**	**0.000**
Late running of buses	1.45	0.89-2.37	0.13	**3.45**	**1.66-7.16**	**0.001**
No indoor rest area	**1.39**	**1.06-1.83**	**0.02**	1.18	0.88-1.60	0.27
Working hours per week	1.01	0.99-1.03	0.26	**1.02**	**1.00-1.04**	**0.02**
Health						
Self-reported health: Good (ref)						
Neutral	**1.82**	**1.36-2.44**	**0.000**	**1.82**	**1.33-2.49**	**0.000**
Bad	**3.30**	**2.22-4.90**	**0.000**	**2.46**	**1.59-3.83**	**0.000**
Stress in the last 3 months	**1.30**	**1.23-1.37**	**0.000**			
Smoker status: non-smoker (ref) vs smoker	**1.42**	**1.05-1.93**	**0.02**	1.04	0.74-1.47	0.81
Exercise: no (ref)						
No vs Low	0.89	0.64-1.24	0.50	0.91	0.64-1.29	0.59
No vs Reg	0.85	0.59-1.23	0.39	0.91	0.61-1.33	0.61
No vs Comp	1.39	0.91-2.13	0.13	0.75	0.45-1.27	0.29
BMI	1.00	0.98-1.03	0.83	1.00	0.98-1.03	0.81
Age: 20-29 (ref)						

30-39	0.77	0.48-1.24	0.28	1.29	0.72-2.31	0.39
40-49	**0.53**	**0.32-0.86**	**0.01**	0.94	0.52-1.71	0.84
50-59	**0.45**	**0.28-0.74**	**0.001**	1.02	0.57-1.83	0.95
60-73	**0.38**	**0.20-0.72**	**0.003**	0.79	0.38-1.66	0.53
Gender: male vs female (ref)	0.95	0.62-1.45	0.81	1.11	0.69-1.78	0.66
Multiple deprivation index	1.00	1.00-1.00	0.33	1.00	1.00-1.00	0.86

Multivariate logistic regressions were conducted using the forward stepwise method. The tables below show the final variables which emerged as significant predictors in the model.

Significant predictors in the multivariate logistic regressions for having to fight to stay awake. OR = odds ratio, CI = confidence intervals, p = significance.

	OR	***CI***	***p***
Sleepiness	2.38	1.92-2.94	0.000
Impaired waking	1.34	1.10-1.64	0.004
Enjoyment from bus driving	0.92	0.86-0.99	0.034
Commuting using public transport	0.58	0.38-0.90	0.014
Self-reported sleep quality: good (ref)			
Neutral	0.36	0.14-0.92	0.033

Note: R^2 = .28, Classification rate = 80.3%

Significant predictors in the multivariate logistic regressions for having a sleep related incident in the last 10 years. OR = odds ratio, CI = confidence intervals, p = significance.

	OR	***CI***	***p***
Fatigue	1.23	1.07-1.41	0.003
Enjoyment from bus driving	0.89	0.83-0.95	0.001

Note: R^2 = .04, Classification rate = 79.2%

Appendix K: GLM ANOVA. Fixed factors: Condition (morning vs Daytime); Time on task (5-10-15-20-25-30-35-40-45); Direction toward or from city. Main effects and interactions. Significant results in bold.

	Condition (morning vs daytime)		**Time on task** (5 min intervals)		**City** (from vs towards the city)		Condition*time on task		Condition*city		Time on task*city		**Participant**	
	F	***p***	***F***	***p***	***F***	***p***	***F***	***p***	***F***	***p***	***F***	***p***	***F***	***p***
KSS (mean)	10.09	**0.002**	0.95	0.478	12.91	**0.000**	0.36	0.939	8.34	**0.004**	0.42	0.090	7.60	**<0.01**
Blinkduration (seconds)	7.08	**0.009**	0.74	0.660	0.07	0.788	1.43	0.189	0.05	0.825	0.43	0.899	32.00	**<0.01**
Long blinkdurations >0.15 s (%)	0.41	0.840	1.96	0.055	0.75	0.387	0.62	0.763	3.27	0.072	0.78	0.620	67.92	**<0.01**
SUS (mean)	13.02	0.000	1.10	0.366	0.17	0.677	0.69	0.699	0.33	0.070	0.62	0.760	16.96	**<0.01**
HRV RMSSD	44.79	**0.000**	1.73	0.095	11.17	**0.001**	1.42	0.193	21.76	**0.000**	1.34	0.230	33.48	**<0.01**
Speed (mph)	47.62	**0.000**	2.19	**0.032**	0.003	0.956	3.13	**0.003**	1.89	0.171	4.45	**0.000**	1.76	0.062
Accelerations (m/s2)	5.99	**0.016**	0.53	0.830	10.37	**0.002**	3.75	**0.001**	0.70	0.401	3.02	**0.004**	5.71	**<0.01**
Decelerations (m/s2)	1.70	0.194	0.92	0.499	4.25	**0.041**	2.49	**0.015**	1.31	0.255	1.92	0.061	6.56	**<0.01**

Appendix L: Summary of the research tasks which influenced each of the proposed solutions.

		Literature review or expertise	Policy review	Focus groups	Manager interviews	Survey	On-road study
Education	**Education relating to sleep and lifestyle**	✓	✓	✓	✓	✓	✓
	Driver responsibility to prioritise sleep and ensure they are well rested prior to duty				✓		✓
Working conditions	**Provide and ensure regular evaluation of suitable facilities for drivers to eat and rest**	✓	✓	✓	✓	✓	
	Improved access to facilities to enable healthy eating	✓	✓	✓	✓		
	Maintain buses to ensure they are always kept in a suitable condition	✓		✓			
Schedules	**Include fatigue risk assessment and mitigation in scheduling and rostering**	✓	✓	✓	✓	✓	✓
	Having safety and fatigue as a main consideration when designing schedules	✓			✓		
	Reducing the variability in shift start times	✓		✓	✓	✓	
	Using forward shift rotations	✓		✓			
	Allowing at least 11 hours between shifts	✓	✓	✓	✓	✓	
	Increasing the number of breaks per duty	✓				✓	
	Avoid having more than three consecutive early shifts	✓					✓
	Avoiding spread-overs	✓		✓			
	Openness to biomathematical modelling	✓					
	Protecting break and rest times	✓	✓	✓	✓	✓	
	Ensure that schedules are better matched with actual running time, at all times of day	✓		✓		✓	
	Providing more flexibility regarding drivers shifts			✓	✓		
	Considering the chronotype of the driver	✓					
Open Culture	**Fatigue risk management**	✓	✓	✓	✓		
	Moving away from a system which is only designed to deal with discipline			✓	✓	✓	
	Increasing the ability to report near misses due to fatigue			✓	✓	✓	

	Improving the relationship between drivers, managers, and traffic controllers			✓	✓		
	Openness to new technology	✓	✓	✓			
	The formation of a fatigue working group, including input from drivers	✓		✓			
Health	**Reducing stress and workload pressure whilst driving the bus**	✓		✓		✓	✓
	Improving the general health of drivers		✓		✓	✓	
	Providing health screening	✓				✓	
	Training for medical practitioners	✓					
	Tracking sleep health				✓		✓

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Safety, Sustainability and Human Resources Panel

Date: **4 September 2019**

Item: **Bus Driver Facility Improvements**

This paper will be considered in public

1 Summary

1.1 This paper provides an update on the Bus Driver Facilities Programme.

1.2 The Bus Driver Facilities Programme aligns with the Mayor's Transport Strategy by ensuring that the bus network is operationally efficient and reliable and therefore meets customer expectations. Well located toilets mean that drivers can access facilities within the time constraints of their breaks, allowing them to resume their bus service as timetabled and avoid unscheduled breaks mid route.

Alignment to the Mayor's Transport Strategy

Strategic Driver / Policy	A Good Public Transport Experience
Primary Outcome Indicators	R2. Public transport reliability and performance (Buses)

1.3 Needing the toilet is a distraction for bus drivers, impacting their ability to concentrate on the road, and is a basic human need. By reducing distractions facing bus drivers, the safety of bus passengers, pedestrians and other road users is improved.

2 Recommendation

2.1 **The Panel is asked to note the paper.**

3 Background

3.1 Bus driver facilities are an integral part of running an efficient and safe bus network. Providing these facilities is as important as other bus infrastructure such as bus stops, shelters and stations. If we are unable to provide facilities we may in some circumstances need to make changes to the bus network.

3.2 Provision of toilet facilities has previously been addressed by a mixture of public and private amenities. While this ensures that the vast majority of drivers have access to a toilet during all hours of operation, some routes are left not fully served; for example, where we have an agreement with a local business for drivers to use their toilets, but that business is not open for all hours of the operating day.

3.3 Those routes where toilets are not available at all times can be addressed by a mixture of permanent or temporary facilities. We install these facilities using TfL's permitted development rights following discussions with the local planning authority and other stakeholders.

3.4 Routes are classified as either Priority 1, 2 or 3 depending on their level of toilet provision, and Table 1 below outlines the route prioritisation as agreed with all key stakeholders including Unite, the bus drivers' union.

Table 1: Priority Classification

Priority	Description
1	Routes without any staff facilities at either terminus
2	Routes that have limited access and run beyond the opening hours of the available facilities
3	Routes with a round trip greater than 150 minutes with a toilet provision only at one end
New	Sites where a route is being extended or introduced that do not have existing facilities

3.5 On 13 February 2018, the Mayor of London, Sadiq Khan, announced £6m of funding to help deliver the toilets on the highest priority routes in order that all bus routes have access to toilet facilities during all hours of operation. This funding enables us to deliver facilities on 42 of the highest priority routes. These are predominantly priority two routes.

3.6 In addition to addressing the highest priority routes on the existing bus network we are also progressing work to ensure that facilities are provided to support planned bus service changes. We will not make changes to the bus network that result in reduced toilet provision.

4 Progress and Forward Programme

4.1 We set an ambitious target of providing facilities on 42 priority routes by the end of July 2019. We have exceeded this target and delivered facilities for 43 routes. This is an unprecedented improvement in the provision of facilities for bus drivers – at the previous delivery rate it would have taken nine years to achieve.

4.2 Of the new facilities provided; 17 are permanent, the remaining 26 are temporary. We are arranging the conversion (utility connections etc) of the 26 temporary facilities to permanent by the end of this financial year. The temporary facilities used are permanent buildings with temporary utility connections and are therefore of a good quality for the users. A list of the sites and routes is included in **Appendix 1**.

4.3 Table 2 below summarises the distribution of routes in scope and the number that now have a facility. We had agreed with Unite the Union (Unite) and bus operating companies in April 2019 to include additional routes in the project scope. This has been possible because of savings made in delivering facilities and reflects changing priorities.

4.4 We will continue to progress the remaining routes and aim to have provided facilities on these routes by autumn 2020 (see footnote 1) A number of these routes are challenging to resolve, for example they may require changes to the bus network to be made which will take time to plan. We will provide more detail on these routes in the next update.

4.5 There is one remaining priority one route – route 124. We are in discussion with the Royal Borough of Greenwich to locate a facility in Eltham to serve this route.

Table 2: Priority routes resolved to date

Priority	Scope agreed with Unite at start of project (March 2018)	Updated scope agreed with Unite (April 2019)	Number of routes that now have access to a facility
1	2	2	1
2	36	37	34
3	4	12	8
Total	42	51	43

4.6 In addition to addressing the priority routes we have installed five facilities this financial year to enable bus service changes. A list of these sites and routes is provided in **Appendix 2**.

5 Ongoing Work

5.1 We will continue to engage with bus drivers, operators and Unite to ensure that as bus routes change, they are all assigned the correct priority within the programme and that new facilities are delivered on the highest priority routes.

5.2 We will continue to identify opportunities for developers to provide facilities for bus drivers as part of Section 106 contributions and other negotiated agreements.

5.3 We will continue to work with stakeholders to ensure we can provide these important facilities with as little impact as possible.

Footnote 1 - The date in paragraph 4.4 was amended from autumn 2019 to autumn 2020, after the error was identified at the meeting

List of appendices:

Appendix 1: List of priority routes with a facility installed since February 2018

Appendix 2: Facilities provided to support bus service changes

List of Background Papers:

None

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Appendix 1: Priority routes that now have a facility (since 2018)

1. Route 370 – Lakeside (*permanent solution)*
2. Route 214 – Moorgate (*permanent solution)*
3. Route 271 – Moorgate (*permanent solution)*
4. *Route H13* – Ruislip Lido *(permanent solution)*
5. *Route 274* – Lancaster Gate *(permanent solution)*
6. *Route 393* – Clapton Pond *(permanent solution)*
7. *Route 345 – Natural History Museum (permanent solution)*
8. *Route 263 – Highbury & Islington Station (permanent solution)*
9. *Route W8 – Chase Farm Hospital (permanent solution)*
10. *Route 455 – Purley (permanent solution)*
11. *Route U7 – Uxbridge Station (permanent solution)*
12. *Route N8 – Hainault the Lowe (permanent solution)*
13. *Route H20 – Hounslow Civic Centre (permanent solution)*
14. *Route 287 – Barking Station (permanent solution)*
15. *Route 196 – Norwood Junction (permanent solution)*
16. *Route 291 – Queen Elisabeth Hospital (permanent solution)*
17. *Route 281 – Tolworth Ewell Road (permanent solution)*
18. Route 174 – Harold Hill
19. Route 290 – Staines Bus Station
20. Route R68 – Kew Retail Park
21. Route 368 – Barking Hart Estate
22. Route 430 – Roehampton
23. Route 130 – Vulcan Way, New Addington
24. Route W15 – Cogan Avenue, Waltham Forest
25. Route 78 – Nunhead St Mary's Road
26. Route R1 – St Paul's Cray
27. Route 415 – Tulse Hill Station
28. Route 273 – Petts Wood Station

29. Route 499 – Gallows Corner, Tesco
30. Route E5 – Toplocks Estate
31. Route H28 – Syon Lane Tesco
32. Route W14 – Woodford Bridge
33. Route 88 – Clapham Common
34. Route 121 – Enfield Lock
35. Route G1 – Hermitage Lane, Norbury
36. Route 163 – Morden Station
37. Route 292 – Colindale Asda
38. Route 42 – Worship Street, City of London
39. Route 288 – Queensbury Morrison's
40. Route 343 – Tower Bridge
41. Route 232 – Pitfield Way, St Raphael's Estate
42. Route K3 – Roehampton Asda
43. Route 321 – Foots Cray Tesco

Appendix 2: Facilities provided to facilitate bus service changes (since January 2019)

1. Route 27 – Glenthorne Road, Hammersmith
2. Route 100 – St Paul's Station
3. Route 224 – Pitfield Way, St Raphael's Estate (covered by route 232 facility above)
4. Route 341 – Waterloo Road, Lambeth
5. Route 386 – Woolwich Arsenal DLR

Safety Sustainability and Human Resources Panel

Date: **4 September 2019**

Item: **Increasing the Maturity of our Health Safety Environment Management System**

This paper will be considered in public

1 Summary

1.1 The purpose of this paper is to present an update to the Safety Sustainability and Human Resources Panel on our progress towards a level 4 maturity of our Health Safety and Environmental Management System, and to note this is supported by the annual HSE plans in place in each of our main business areas.

2 Recommendation

2.1 **The Panel is asked to note the report.**

3 Background

Health, Safety and Environmental Management Systems (HSEMS)

3.1 Our HSEMS describe how we will run safe operations. They are legally required for our rail businesses. They define HSE roles and responsibilities and let our people know what we want them to do. The goal is to anticipate, prevent and mitigate harm to health, safety and the environment. They reflect our HSE Policy. The success of our HSEMS hinges on the attitudes and behaviours of people in the organisation sometimes referred to as the 'safety culture'.

Risk Management Maturity Model (RM3)

3.2 In addition to making sure that the health and safety of everyone associated with the rail industry is controlled, the Office of Rail and Road (ORR) have a key role in securing sustained improvement in health and safety performance. One way they aim to achieve this is by encouraging railway businesses to achieve excellent health and safety management.

3.3 To do this they developed the RM3 model in collaboration with the rail industry, as a tool for assessing an organisation's ability to successfully manage health and safety risks, to help identify areas for improvement and provide a benchmark for year on year comparison. It helps to describe what a good safety management system looks like.

3.4 The model follows the Health and Safety Executive's framework for successful health and safety management (HSG 65) which is the most widely adopted model of successful health and safety management in the UK. It also draws on

knowledge from incident reviews. This supports its use across the non rail parts of our business.

3.5 The model provides criteria for measuring management capability against five maturity levels (ranging from ad-hoc through managed, standardised, predictable and up to excellence) across 26 criteria, which are identified as being essential areas of a health and safety management system. These are shown in Appendices 1 and 2.

3.6 The model is not an audit tool, but a model to structure discussions about evidence and where to go next.

Why improve our maturity?

3.7 Managers control risk day in day out but managers are people and performance varies, people can get things wrong from time to time. Making a mistake should not result in someone getting hurt or regulatory compliance issues. The more effective, more mature, our HSEMS are i.e. if we choose to go beyond minimum legal compliance, the more resilient we are to these variances in performance.

3.8 Using the RM3 model it is possible to identify the gap between the 'work as imagined' of the written HSEMS and the 'work as done' by actions taken at the 'sharp end'; the 'here and now' of task performance. Improvement activity can then be identified to strengthen risk controls and make their application more consistent.

4 Current status

4.1 The current maturity of our HSEMS in the different parts of the business is shown in Appendix 3. Our businesses are generally at the standardised level (Level 3) with pockets of performance at Level 4.

5 Next Steps

5.1 The HSE improvement plans for Surface Transport, London Underground and Major Project Directorates map to the RM3 criteria. The activities listed in section 5.2 are ongoing which will strengthen our maturity. The main area they are focussing on is changing our culture so that:

(a) Leaders take responsibility for developing, leading and promoting a positive culture in the organisation that supports effective HSE risk management;

(b) Staff believe their views will be listened to and acted upon;

(c) There is belief that management reviews result in changes which are effective in controlling HSE risks; and

(d) Individuals understand the importance of completing corrective actions and the organisation can demonstrate a learning culture.

5.2 Improvement activity in 2019/20

a) Implementation of the Major Projects Directorate, London Underground and Surface Transport HSE improvement programmes. Each of the improvement activities maps to the RM3 criteria. In this way the improvement programmes not only addresses our scorecard ambitions of reducing injuries and the severity of injuries but also strengthens the overall management of our risks.

b) The LU Leadership team agreed to focus on 6 criteria:

i. Leadership;

ii. Worker Involvement and Internal Co-operation;

iii. Organisational Culture;

iv. Incident investigation;

v. Management Review; and

vi. Corrective Action.

Specific actions to strengthen these form part of the quarterly HSE meetings. These themes also have a strong ‘culture’ element to them which supports the fact that the success of our HSEMS relies on the attitudes and behaviours of people in the organisation;

In addition, in recent years, LU (and TfL) has gone through a significant period of change. We have carried out significant organisation restructures in the teams who have responsibility for discharging key responsibilities in the H&S management system – i.e. operations, maintenance, engineering, health, safety and environment and projects teams. In the opinion of the ORR, this change has been handled effectively with no adverse impact on safety. However, we consider it is timely to review and reflect on our H&S arrangements to ensure our approach remains robust, follows good/best practice and is being discharged effectively. A peer review of our arrangements is to be undertaken and is expected to be complete by the end of the year.

c) Surface Transport’s Project and Programme Delivery (PPD) and CPOS directorates are validating a tool to monitor progress towards a Level 4 maturity against all 26 of the RM3 criteria. Once validated this will then be rolled out across TfL. The tool identifies what good looks like against the Level 4 criteria and allows directorates to score themselves;

d) After validation of the tool, re-scoring each area against the revised RM3 criteria to show percentage complete towards Level 4. This will to provide better insight into progress on strengthening the safety culture elements of our plans.

List of appendices:

Appendix 1 – Description of RM3 Maturity Level

Appendix 2 – overview of the Risk Management Maturity Model's (RM3) themes and criteria

Appendix 3 - RM3 scores

List of Background Papers:

None

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Appendix 1

Description of RM^3 Maturity Levels

Ref. Office of Rail and Road RM3 2019 The Management Maturity Model

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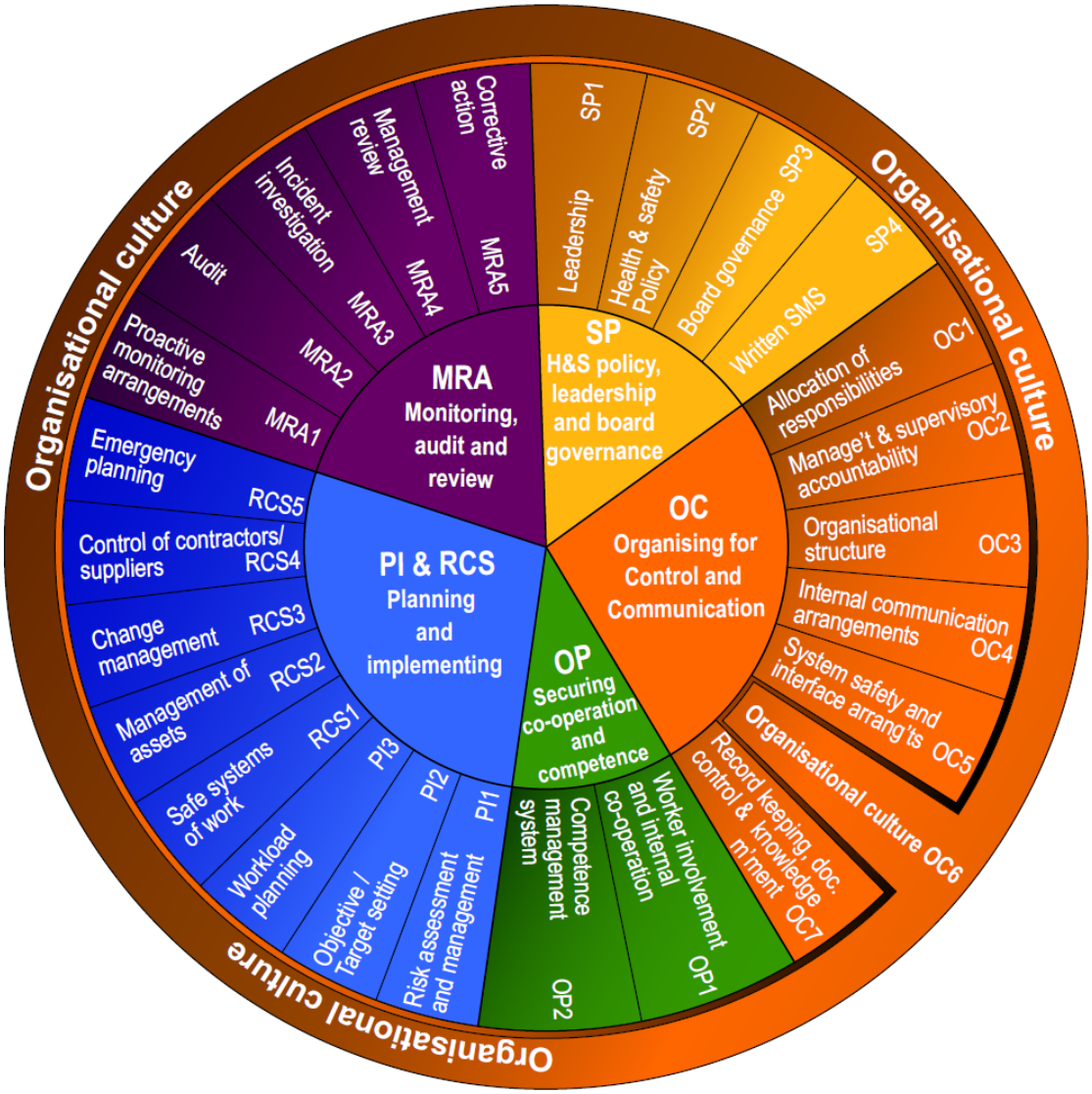
Appendix 2

Overview of the Risk Management Maturity Model's (RM3) themes and criteria



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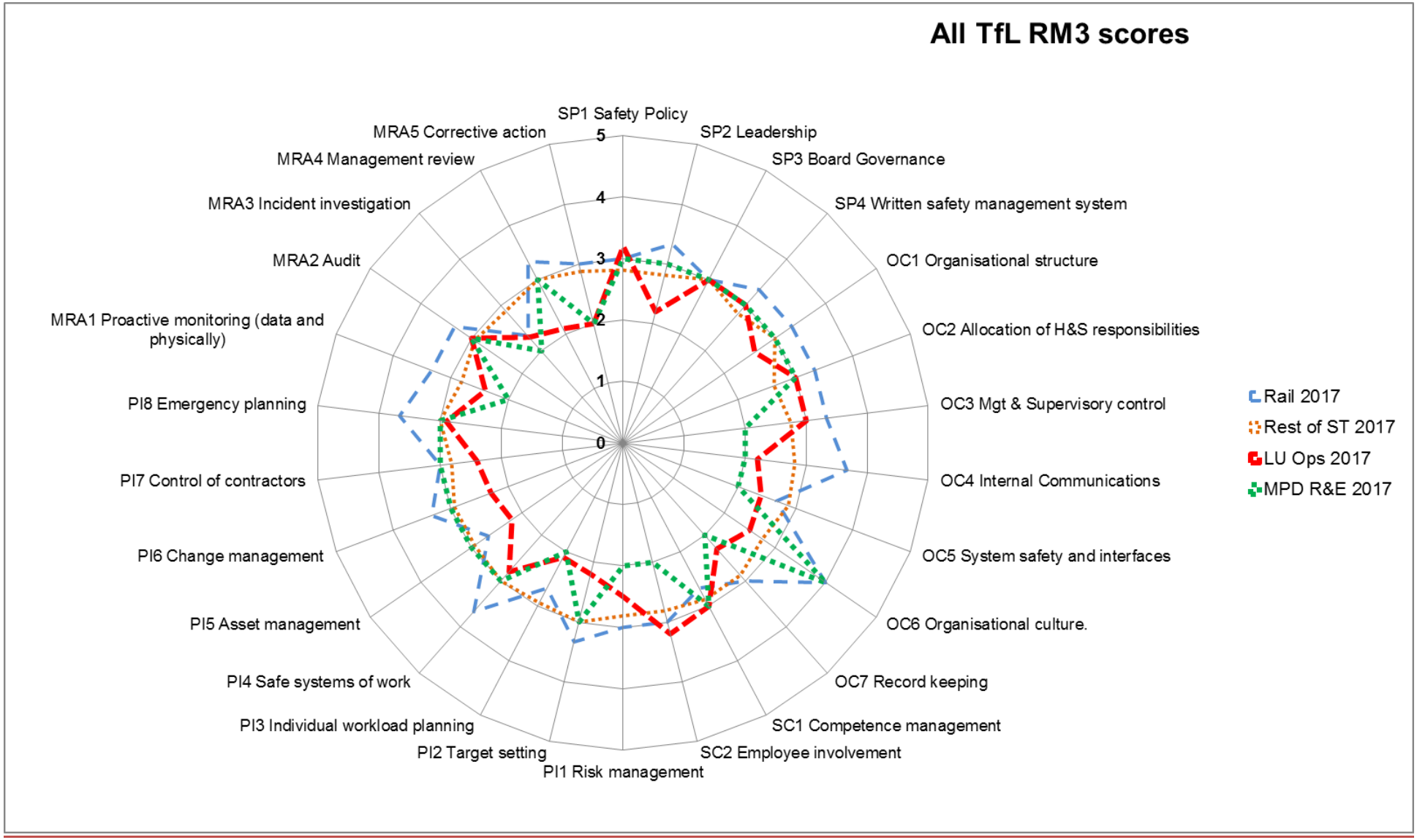
Appendix 3 – RM^3 scores



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Safety, Sustainability and Human Resources Panel

TRANSPORT FOR LONDON
EVERY JOURNEY MATTERS

Date: **4 September 2019**

Item: **Major Events**

This paper will be considered in public

1 Summary

1.1 This paper has been produced in response to a request from the Panel regarding major events in London, how the environmental impact is assessed and what actions are taken to minimise the impact. The paper also highlights roles and responsibilities through the planning process for major events.

2 Recommendation

2.1 **The Panel is asked to note the paper.**

3 Background

3.1 London's place on the world stage makes it an attractive location for event organisers. Each year there are numerous major events that take place, including: the London Marathon; Prudential RideLondon; Notting Hill Carnival; the New Year's Eve Fireworks event; the London Triathlon; the major ceremonial events including Remembrance Sunday, State Opening of Parliament, Trooping the Colour events, state visits, for example: US President Donald Trump; as well as numerous half marathons, ceremonial events, marches and major demonstrations.

3.2 While the annual major events listed above take up the majority of the summer months each year, London has also hosted numerous large-scale events in the past, including the Olympics, two Tour de France Grand Departs, UEFA Champions League finals, the Rugby World Cup, the Cricket world Cup, a Pope's visit and the Royal Wedding.

3.3 These events take months and sometimes years of planning, working across the GLA, local Authorities and Government in some cases.

4 Assessing and Approving Major Events

4.1 An event organiser will normally approach a Local Authority (LA) for permission to hold an event in their borough. The LA will assess the application and should engage with all stakeholders including emergency services and TfL through a Licensing Operational Safety Planning Group (LOSPG) process.

4.2 The LOSPG process allows stakeholders to make assessments on the potential impact to their organisation from an event and requires that the organiser presents comprehensive Health and Safety information, medical provisions, commercial / branding permissions, environmental and Equality Impact Assessment (EqIA) considerations, communications strategies, financial responsibility, crowd safety management and traffic management plans.

4.3 It is important to remember that even if an event is solely on the TfL Road Network, the licensing approval remains the responsibility of the LA in consultation with TfL.

5 Operational delivery

5.1 In most medium to large scale events, TfL in conjunction with the LA, would look to set up a Traffic and Transport (T&T) subgroup which will report back to the LOSPG.

5.2 The purpose of the T&T subgroup is to assess the impact of road closures, bus diversions and cycle and pedestrian diversions, as well as impact on other modes of transport, e.g. London Underground, train operating companies, Docklands Light Rail, and London River Services.

5.3 All major events will have an impact in our ability to deliver a reliable service to our customers and we work closely with the LA, the organiser and other stakeholders to find practical solutions to minimise the disruption.

5.4 As part of the impact mitigation planning, Bus services can be diverted, curtailed or facilitated through strategic closures points to maximise services to the areas and communities affected by the road closures.

5.5 Road closure times are scrutinised and kept to a minimum wherever possible and extensive work goes into assessing the organiser's traffic management plans as well as their stewarding plans. This is to make sure the roads are reopened according to the plan and that the agreements reached through the planning process are adhered too. .

5.6 While looking at the operational requirements to deliver our public transport services, we are also conscious of 'the economic benefits and exposure these events bring to London on the world stage. We try to balance this while still delivering a reliable network.

5.7 In recent years there has been a significant increase in the use of Hostile Vehicle Mitigation measures (HVM) by the Metropolitan Police Service (MPS) or an organiser under consultation with the MPS. This enhanced security provision has had an impact on the traffic management plans and the length of time road closures have to be in place, as the derigging of HVM adds time to the reopening process.

6 Environmental Impact

6.1 The LAs, Mayor's Office and agencies are strategically aligned with their aims and objectives in terms of environmental impacts for events.

6.2 The LAs and agencies will have an environmental impact statement as part of the planning process and there is opportunity to influence the environmental requirements as part of the agreement to deliver the event with the organiser.

6.3 On the larger scale events, there is championing of best practice across the authorities. For instance, there is agreement that eliminating single use plastics on events is the ambition, but it requires local and political engagement to deliver this. On this year's Prudential RideLondon event, the use of single use plastics was kept to a minimum.

6.4 For the smaller scale events, financial and resource limitations are a big burden for smaller event organisers.

6.5 The responsibility for cleaning and removing waste from an event lies with the LA and the organiser. Discussions do take place on how best to manage this and also what type of waste is expected, for example, London Marathon's wastes profile is different to Prudential RideLondon – one is a running event where disposable drinking vessels are used, the other is a cycle event where riders predominantly use their own bottles and containers for water collection.

6.6 We take an active role in assessing and trying to mitigate the air quality impact of major events in London.

6.7 Event organisers are subject to Ultra Low Emission Zone (ULEZ) controls There are some exemptions in place for certain types of 'Showmen's Vehicles' that have been modified or specially constructed.

6.8 We are committed to improving air quality in London and we work with organisers of major events to help minimise the environmental impact they have. One way in which we do this is by working with event organisers to encourage people to take up active travel and use public transport when travelling in London on event days, and where possible avoid driving in the affected areas.

6.9 Another way is about how we manage traffic, including road closures and diversions when major events take place across London. We take into account how the road closures may impact a local community in terms of pollution from stationary traffic or diverted bus routes. This is sometimes difficult to balance, as the closing of roads invariably causes congestion on diversion routes. This is why we try to maintain key arterial routes around the event footprint wherever possible.

6.10 We work to develop plans that can manage the movement of people and vehicles around the event footprint, making sure bus services are maintained as best as possible and local residence are allowed access where required.

6.11 When delivering the event, the Surface Transport Network Management Control Centre plays an important Command, Control and Communications role in observing the road closures, implementing the bus diversions, utilising the signal strategies and providing real-time information to our customers. This works to keep London moving around the footprint of the event and minimising the environmental impact from the displaced traffic.

6.12 It should be recognised that the amount of influence we have varies from one event to another, particularly those that take place on borough roads such as Notting Hill Carnival. Our Director of Network Management and the Head of Control Centre Operations, who manage traffic disruption and event planning, has tasked their team to work with organisers to minimise the impacts on London's air quality as part of our event planning process.

6.13 Regarding noise pollution, there has been an increase in the number of festivals being granted licences across London in recent years. This has not only caused some issues with noise pollution but also how ingress and particularly egress from the 'venue' is managed.

6.14 Noise from an event is assessed through the licensing process and premises licences can be conditioned under the licensing act to minimise noise nuisance. This is something that is managed through the event planning process and at a local level at the 'venue' by the relevant Local Authority.

6.15 The increase in licensing for festivals has had an impact on our ability to manage the road space. We are seeing issues with egress from venues, were large numbers of people are leaving the sites and this is having an impact on bus services and traffic in the area.

List of appendices:

None

List of Background Papers:

None

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Safety, Sustainability and Human Resources Panel

TRANSPORT FOR LONDON
EVERY JOURNEY MATTERS

Date: **4 September 2019**

Item: **Pan-TfL People Plan 2019/20**

This paper will be considered in public

1 Summary

1.1 This paper introduces the pan-TfL People Plan for 2019/20.

2 Recommendation

2.1 **The Panel is asked to note the paper.**

3 Background

3.1 Our People Plan sets out our people priorities for the current performance year.

3.2 The priorities within the plan are those which will enable us to deliver the Mayor's Transport Strategy and the TfL Business Plan.

3.3 This annual plan includes projects and initiatives that will feed into our five year TfL People Strategy which is currently in development. Ultimately, the year on year deliverables of the plan contribute to our people vision of making TfL "a great place to work for everyone."

3.4 Going forward our people plan will be revised annually in alignment with the TfL business planning cycle, ensuring that we have the right people and capabilities to deliver the Business Plan.

3.5 Local area people plans with priorities and work packages for each of the major TfL business areas have also been developed. Their themes align broadly to the pan-TfL themes, with tailored solutions for each area that meet business need.

List of appendices:

Appendix 1 – Pan-TfL People Plan 2019/20

List of Background Papers:

None

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Appendix 1

TfL People Plan

2019/20

Contents

Key terms

Below are the terms that we use when referring to people activity across our organisation. These will be used across our people-related documentation.

People vision – the strapline that describes our aspiration and what we are aiming towards with all our people activity, both in the short, medium and longer-term. Our people vision is for TfL to be a great place to work for everyone.

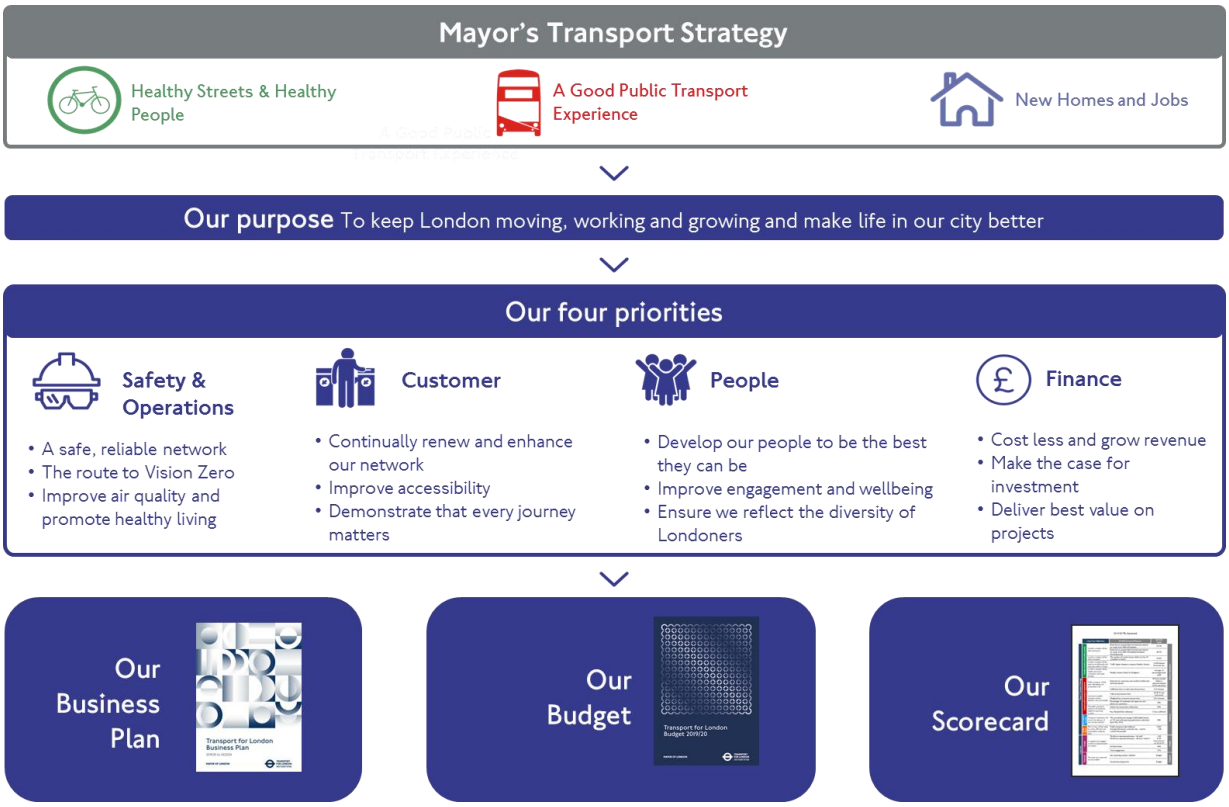
Five year People Strategy – the five year strategy sets out key strategic themes and longer-term interventions that work towards achieving our people vision.

TfL People Plan – the annual plan sets out pan-TfL people activity being delivered. The plan aligns to the aims of the TfL People Strategy, providing deliverables with milestones that are monitored throughout the year.

Local people plans – these plans set out the annual priorities for each of the major business areas. The priorities in these plans are aligned to both the pan-TfL plan and the People Strategy.

Why do we have a TfL People Plan?

The below diagram outlines the context we operate within – everything we deliver is framed by the Mayor's Transport Strategy and our purpose; to keep London moving, working and growing.



People are one of our four core priorities, along with Safety & Operations, Customer and Finance.

To ensure we keep our people at the heart of everything we do, we have developed a people vision for TfL:

"To be a great place to work for everyone"

To achieve our vision, we will take the following approach to planning our people activity.

- Our vision is the overarching goal that drives all our people activity.
- The five year People Strategy sets out our strategic aims to address the biggest challenges in our Business Plan and help us deliver it.
- The 2019/20 People Plan (this document) outlines the priorities for the current financial year. There will be one of these for each year of the five year strategy, aligned to our strategic goals and focusing on our current business issues.
- Localised people plans will sit below the pan-TfL plan and outline people interventions that are specific to each area. These link to the priorities in the pan-TfL plan and ultimately work towards achieving the aims of the five year strategy.

What is the business context driving our people activity?

We are facing a number of challenges that impact our people, as well as emerging ones that will impact us in the near future. We need to respond to these challenges effectively in order to work towards our vision of making this a great place to work for everyone.

The current challenges are:

- We continue to face significant financial challenges, as we adjust to the loss of our government grant.
- We will continue to deliver organisational change and continuous improvement over the coming years.
- As an organisation our operating model is changing and expanding into new areas (e.g. consulting) where we will require new skills and ways of working.
- Our workforce spans five generations who are motivated in different ways and naturally have different preferences when it comes to how they engage with work and the world around them.
- Compared to the UK norm our employee engagement and change and leadership scores are low.
- We have a challenging business plan for the next five years, which needs an aligned People Strategy and year on year people plans to help us deliver.
- As an HR function we have gone through transformation and we now need to embed and deliver our new ways of working to ensure we continue to support the business to deliver to their people priorities.

We are committed to improving engagement and the diversity of our workforce. Our TfL scorecard includes three people-related measures:

1. Engagement
2. Workforce representativeness
3. Inclusion index

Our Plan for 2019/20 must deliver improvements in these areas, whilst addressing the challenges outlined above.

See appendix for a further list of things that impact us, or we expect will impact us in the coming years. This list is not exhaustive and will continue to evolve over the life of both the 19/20 People Plan and the five year People Strategy.

How did we determine our 2019/20 priorities?

Following the stand up of the new HR function post-transformation, we began to look in more detail at the people priorities for 2019/20.

We assessed people activity already underway or in the pipeline within existing budgets for 2019/20 through discussions with our HR teams. Our HR Business Partnering teams fed in the key business priorities and the HR Strategy Hub teams provided their proposed interventions for the year.

Conversations have taken place across our HR teams to align what we are delivering and ensure that as a function we support the business in meeting their Scorecard, Business Plan and ultimately the Mayor's Transport Strategy.

We have also begun a prioritisation exercise to ensure our HR function is appropriately resourced to support the business in delivering their key people activity. This includes assessing proposed activity against budgets, with approval for funding being routed via HRLT, the People Leadership Group or the Executive Committee as appropriate.

We recognise that the planning process for this year was not optimal; this was due to the stand up of the new HR function at the start of the financial year. For the 2020/21 People Plan and future years, we intend to begin people planning conversations once the Business Plan and budgets are released, assessing business priorities alongside HR's budget for the next year. This will enable us to have plans ready for the start of the financial year. A full process for this will be shared later in the year.

What are our TfL people priorities for 2019/20?

We have identified five people priorities for 2019/20 and below is a summary what we are delivering and supporting the business with:

1. **Delivering and embedding organisational change and modernisation**
    - Various programmes across TfL
    - Creation of new functions

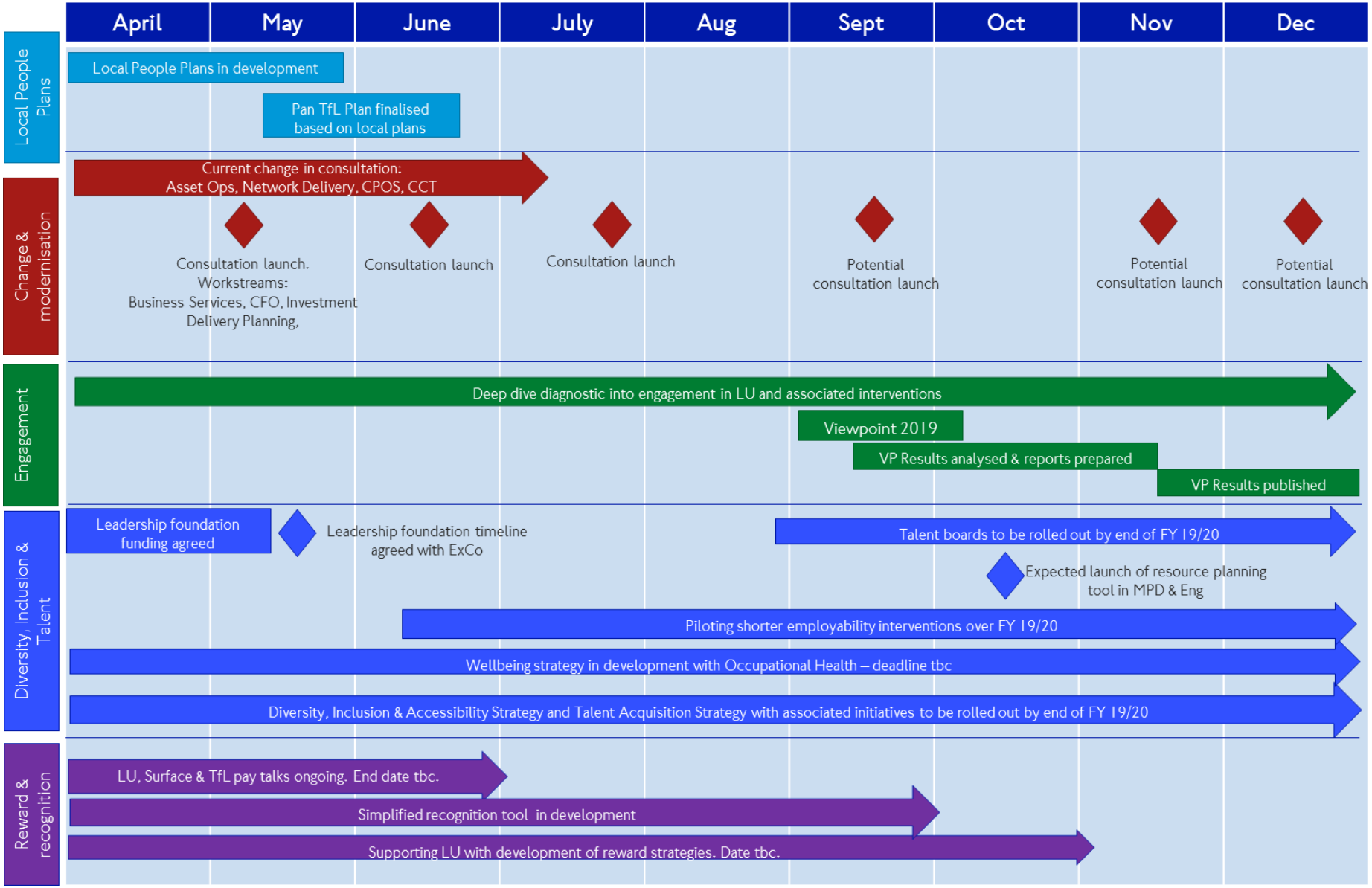
2. **Improving engagement across the organisation**
    - Looking into the culture in London Underground (through a diagnostic) and any resulting initiatives
    - Viewpoint engagement survey 2019 – launching in September, with results being shared with Managing Directors at the end of October
    - Commissioner's events throughout the year (e.g. monthly senior leadership briefings for top 100 leaders and annual event for top 300 leaders)

3. **Developing an inclusive workforce that is representative of the city we serve**
    - TfL Leadership Foundation – a programme of work that will offer leaders at all levels a range of activities to help them be the best they can be to deliver our ambitious business plan and make this a great place to work for everyone. This includes coaching, a strengths based 360, trialling a leadership app and leadership events.
    - Employability programmes – such as our graduate and apprenticeship schemes
    - Gender and ethnicity pay gap reporting and action planning
    - Development of the Diversity, Inclusion & Accessibility Strategy and the Health & Wellbeing Strategy

4. **Attracting, developing and retaining talent**
    - Resourcing tool – the development of a tool including a skills capture, launched initially via a trial in Major Projects and TfL Engineering in summer 2019. The tool will help teams better prioritise and allocate resource to projects / initiatives
    - Succession planning for senior roles across the organisation
    - Employability programmes - such as our graduate and apprenticeship schemes

5. **Rewarding & recognising our people**
    - Supporting our business to develop appropriate reward strategies
    - Introduction of a new online reward hub for employees, putting all employee benefits in one place, as well as changes to how we manage recognition awards
    - Leading pay talks at both London Underground, Surface and TfL levels (annual activity)

This timeline shows our people activity between April and December 2019. This is subject to change depending on progress of activity and alignment to localised people plans.



What outcomes do our priorities contribute towards?

Our priorities for this year aim to address some of the critical challenges we face as a business. Delivering against these priorities aims to contribute to key scorecard targets and financial savings. The table below outlines this.

Priority	Challenge(s) this addresses	Contributes to
Change and modernisation programme	Financial situation; business plan	Net operating surplus; investment programme
London Underground culture diagnostic	Engagement	Total engagement
Viewpoint 2019	Engagement	Total engagement
Leadership foundation	Ability to develop and retain talent and capability	Total engagement; savings target; all staff workforce diversity; band 5+ workforce diversity
Resourcing tool (Major Projects & TfL Engineering)	Ability to attract, develop and retain talent and capability; succession planning	All staff workforce diversity; band 5+ workforce diversity; total engagement
Employability programmes	Ability to attract, develop and retain talent and capability	All staff workforce diversity; band 5+ workforce diversity
Diversity, Inclusion and Accessibility Strategy	Workforce representativeness; building capability and talent; succession planning; Inclusion	All staff workforce diversity; band 5+ workforce diversity, inclusion index; percentage of Londoners who agree we care about our customers
Health and Wellbeing Strategy	Wellbeing; inclusion; organisational stress; workforce representativeness	Reduction in customers and workforce killed and seriously injured; percentage of Londoners who agree we care about our customers; total engagement; all staff workforce diversity; band 5+ workforce diversity
Reward portal	Engagement	Total engagement
Recognition tool	Engagement	Total engagement
Supporting our business to develop appropriate reward strategies	Financial situation; business plan; engagement	Net operating surplus; investment programme

How will activity be monitored/ measured this year?

At a local level, TfL People Plan activity will be closely monitored by the owners of each of the work packages, with HR Strategic Planning & Governance holding accountability for the progress of the plan as a whole.

Progress against the plan will be reported to the HR Leadership Team in week two of each period to align with the Performance Executive Committee cycle (which takes place in week three). We will update using dashboards that highlight successes and challenges from the previous period, report progress against milestones, flag risks and give commentary on expected activity in the upcoming period.

The periodic updates given to the HR Leadership Team will be fed into Performance Executive Committee meetings where necessary.

There will also be a quarterly review of progress against the People Plan, which will also consider where activity may need to be re-prioritised to ensure our deliverables can be met. This quarterly update will feed into People Leadership Group meetings, with any risks or issues in the interim being escalated if necessary.

Once the Business Plan for next year is released, we will begin prioritisation of our people activity for 2020/21, in alignment with Business Plan priorities.

At the end of the People Plan cycle (end of Q4) we will conduct a full review of the plan including lessons learned ahead of next year.

What does this mean for me?

Throughout the current financial year, interventions will be put in place to meet our People Plan priorities. How this translates in each business area will vary and will therefore impact teams differently. For example, in Professional Services there is an emphasis on organisational change; this is not the case in other areas.

Alongside the TfL people priorities and associated activity for 2019/20, there are localised people plans which are tailored to the needs of each of the major business areas.

For 2019/20 the following areas will have People Plans:

- London Underground
- Surface
- Health, Safety & Environment
- Major Projects
- TfL Engineering
- Customers, Communications and Technology
- General Counsel
- Human Resources
- Finance

If you wish to find out more about our people priorities for your local business area, please contact your Senior HR Business Partner.

Appendix - work being scoped

As well as activity already underway aligned to our priorities, we also have a number of work packages currently being scoped. In delivering these, this will also support delivery of our priorities now and in the future.

Area	Work package
Diversity, Inclusion & Talent	Full Leadership Foundation roll out
	Potential changes to our performance and development process
	Review of our assessment and selection process and competencies
	Looking at technology options for how we manage our talent acquisition and development (including CRM)
	Wellbeing app for employees
	Carer's passport
	Disability roadmap interventions
Compensation & Benefits	Pay for performance review
	Total reward statements as part of the reward hub
Pan-HR	Further exploration on engagement (pending outcomes of London Underground diagnostic)
	GLA bodies collaboration activity
HR/Business Services	Hire to retire process work

Contact

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Safety, Sustainability and Human Resources Panel

Date: **4 September 2019**

Item: **Human Resources Quarterly Report**

This paper will be considered in public

1 Purpose

1.1 To provide the Safety, Sustainability and Human Resources Panel with an update on key Human Resources (HR) led activities and performance for Q1 2019/20.

2 Recommendation

2.1 The Panel is asked to note the report.

3 Background

3.1 As outlined at the July Panel, the Q1 HR Quarterly Report has been redesigned to focus on the five key themes contained within Our People Plan.

3.2 The TfL People Plan is the annual plan that sets out pan-TfL activity being delivered in relation to our people. The five themes contained within the 2019/20 plan will form the structure of the HR Quarterly report, providing updates on the activity and deliverables taking place within these per quarter.

3.3 Information on how these activities contribute towards the delivery against the People Strategy, and our longer term vision will also be included within later versions of this HR Quarterly Report when the People Strategy has been finalised.

List of Appendices:

Appendix 1: HR Quarterly Report

List of Background Papers:

None

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Appendix 1

HR Quarterly Report Q1 2019/20

4 September 2019

HR Quarterly Report – 2019/20 Quarter 1 Update

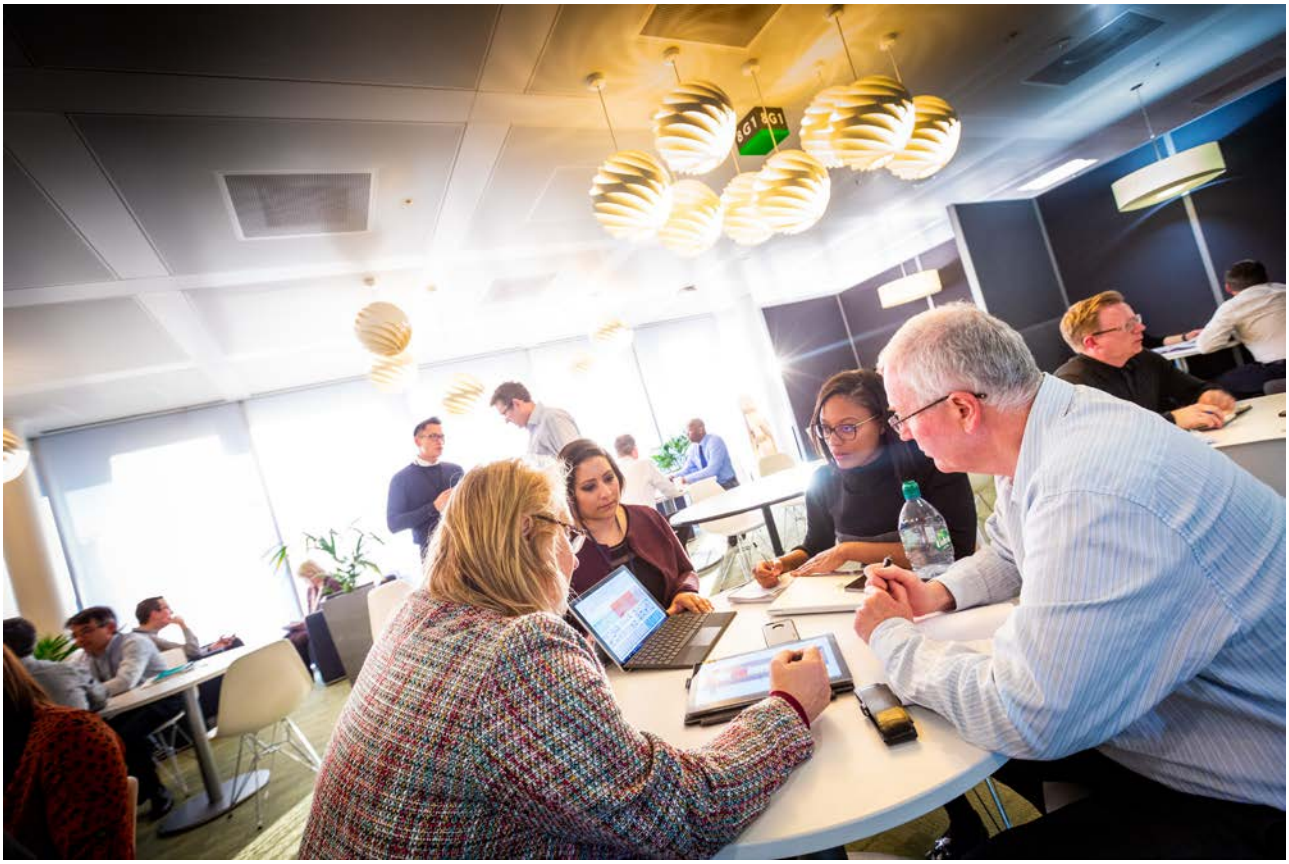
Introduction

This Human Resources (HR) Quarterly Report provides an overview of key people activity and deliverables that have taken place in the first quarter of 2019/20.

This report has been redesigned to demonstrate how our activity aligns to our key areas of focus for this performance year, as outlined in our People Plan. The report will continue to provide updates on our people measures included on the TfL Scorecard.

In the next quarter we hope to finalise our People Strategy, which will set the strategic direction for our people activity over the next five years. This will set longer term aspirations for our people and how we plan to achieve this.

Diversity & Inclusion data will be contained within the Diversity & Inclusion Impact Report, which is a more holistic publication, bringing together accessibility and the work to improve the experience of our customers as well as our people.



People Scorecard Measures 2019/20

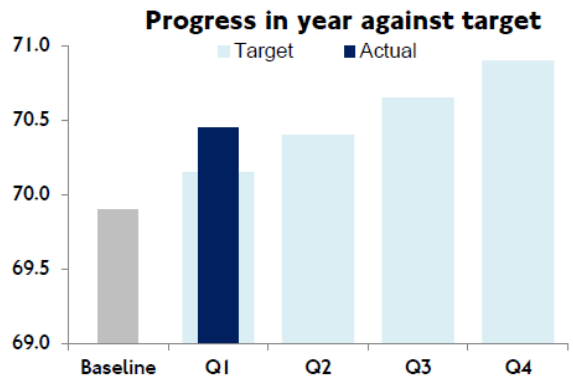
There are four people measures on the TfL Scorecard for 2019/20. These are:

People	2018/19 Result	2019/20 Target
Foster a workforce representative of London		
Workforce Representativeness Index - All Staff	69.9%	70.9%
Workforce Representativeness Index - Director/Band5	37.8%	38.3%
Engage our people		
Total Engagement Index	56%	57%
Build and inclusive environment		
Inclusion Index	43%	46%

Workforce Representativeness Index – All Staff

Our scorecard target for the all staff workforce representativeness index (WRI) was +1 per cent on last year's end of year score of 69.9 per cent.

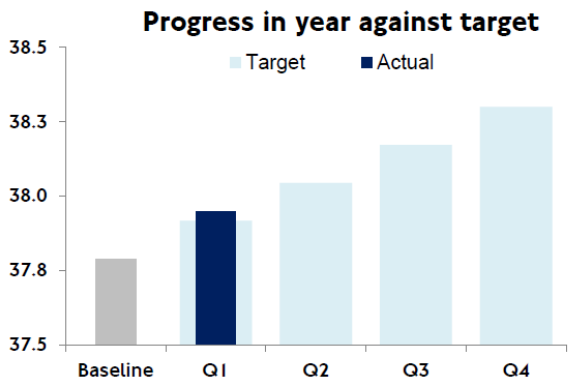
In Q1, our all staff WRI increased by 0.55 per cent, to reach 70.45 per cent, ahead of target. This was driven by significant increases in declaration of BAME and disabled employees, resulting from our ongoing disclosure campaign.



Workforce Representativeness Index – Band 5+

Our scorecard target for the Band 5+ WRI was 0.5 per cent up on last year's end of year score of 37.8 per cent. This scorecard measure includes our senior managers at Band 5 and above.

In Q1, our Band 5+ WRI increased by 0.15 per cent to reach 27.95 per cent, slightly ahead of target. There were mixed results for this measure, with the number of female and BAME senior managers increasing. However this was tapered by a decrease in senior managers declaring as a minority faith, disabled and LGBT.



Improving engagement across the organisation

We are committed to making TfL a great place to work for everyone, caring for our people, and supporting them to be the best they can be. This is the only way we can truly deliver for London. The best indicator of how well we are doing at this are our Viewpoint engagement scores, which tell us how our people feel about working for us and what needs to be better.

Our TfL scorecard target for 2019/20 is 57 per cent, which is up on the 56 per cent recorded last year. The following section outlines activity underway to help drive improvements in our employee engagement.

Deep Dive Diagnostic

Our annual Viewpoint Survey measures our employee engagement which, along with our Inclusion Index, provides a temperature check and shows key drivers of engagement in each business area.

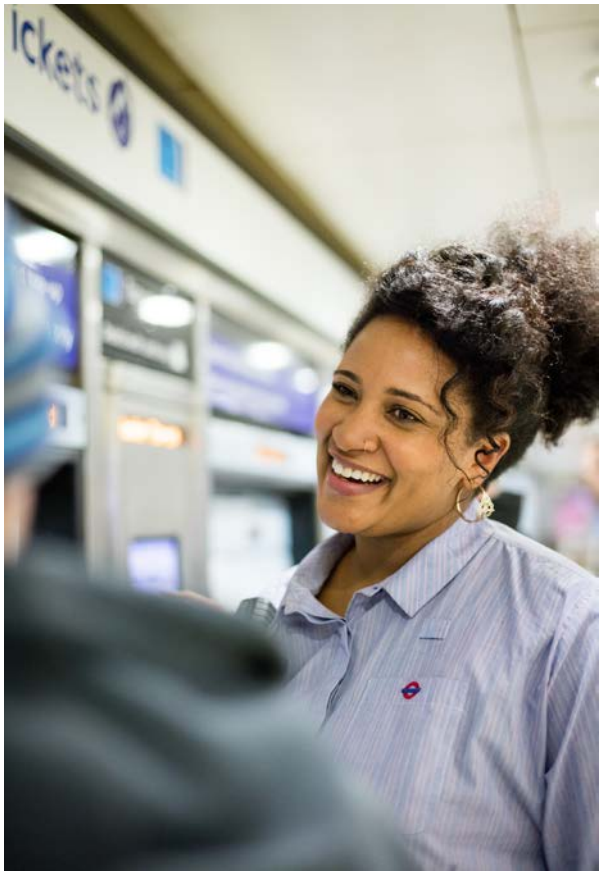
A separate deep dive diagnostic into the causes of low engagement within LU was therefore commissioned to generate evidence-based hypotheses as to why engagement scores have not improved. These have then been explored further in focus groups and in depth interviews.

The outputs of this research will propose interventions which are likely to be the most effective in improving our employee engagement in LU. This work is currently ongoing with initial results going to the TfL Executive Committee in late September.

Viewpoint 2019

Planning work has started ahead of the 2019 annual Viewpoint survey. The survey will be open between 9 and 27 September, with initial results available in November. We will be updating the Panel members on the results ahead of the TfL Board on the 22 January 2020.

Determining our approach to action planning for this year, and how this will tie in with the outputs of the deep dive diagnostic is underway, along with developing a communications plan to maintain our high response rate achieved last year.



Other Activity

Engagement is not only about one off interventions or analysis; there are continuous activities throughout the year to drive engagement and highlight key themes which we know are important to our people.

The majority of this activity takes place through our internal communication channels, such as our employee magazines, our intranet and more recently our Yammer tool, promoting key messages and information.

One of the key messages we have been promoting is sharing best practice, providing useful material and ideas as to what works well in other areas. Claire Mann, Director of Bus Operations created a film outlining what best practice looks like in Bus Operations which had one of the highest Viewpoint scores last year for operational areas.

At the recent Commissioner's top 300 event held on the 19 June, each senior manager visited one of our operational areas across the network and had to undertake a series of tasks with our operational employees focussed around the four priorities: safety and operations, customer, finance and people. The thread throughout the day was our people; if we don't get it right for our people we won't be able to deliver against our other priorities.

Attracting, developing and retaining talent

This theme covers all activities to ensure we have the right people and capabilities to deliver our business plan and the Mayor's Transport Strategy.

Resource Planning Tool

TfL's new operating model requires business areas to work together on pan-TfL resource planning initiatives. This means we need to know who we have, where they are working and how they are utilised across projects. Historically this has been managed at a local level with multiple spreadsheets but with the new transparent ways of working, the sharing of resources and tighter controls on costs, a central tool is required.

A pan-TfL project is underway, led by Engineering and MPD, to help us make better use of our people resource. Following extensive market research, we are currently testing a Microsoft Online solution to see whether it will support our requirements to better track and forecast our resource requirements. This trial will be complete in October when a decision will be made regarding whether to roll this tool out across the organisation.

Employability Programmes

Supporting those who face barriers to employment is a core element of the Mayor's Skills for London Strategy. It is also a key priority of the Strategic Transport

Apprenticeship Taskforce (STAT), chaired by our Commissioner; to increase diversity and social mobility through employability programmes leading to apprenticeships and employment.

We currently target multiple groups based upon their protected characteristics or their readiness for work, and schemes currently in place include Steps into Work, Ex-Offenders, Ex-Services and work placements.

There are however many other groups which are not yet catered for, such as people impacted by homelessness and young people leaving the care system which have been identified as areas for further development.

Our Diversity, Inclusion and Talent team are currently developing a proposal to streamline these employability routes into work, split by their previous education and experience level, rather than by specific characteristic. This will implement a simpler pathway for those seeking routes into work. The three routes proposed are:

- **Ways in to Work**: for those with limited or no previous work experience
- **Routes back to Work**: for those with significant experience of work
- **Education to Work**: for those in full time education

The next steps in this programme are to establish a working group with employees from across the organisation. This group will then draft design principles for these programmes, with initial pilot schemes scheduled for Q4 later this year.

Recruitment Activity

Effective recruitment activities are essential for us to be able to develop a diverse and capable workforce, which will allow us to deliver our business plan, whilst also ensuring we reflect the city that we serve.

One of the challenges we face in the recruitment process is our ability to be able to attract a diverse a diverse range of candidates. Recent high volume campaigns, in particular in London Underground have trialled different approaches to ensuring that we have diverse candidates, even for roles which are close listed to internal employees meaning we are recruiting from an already under representative pool.

In Q1, we recruited for the Customer Service Supervisor (CSS) role within London Underground. To ensure that we were able to attract diverse candidates, we explored a variety of attraction activities including:

- Accessible job adverts – making these readily accessible to this with visual or other impairments.
- Heavily advertising the roles via internal communications channels, such as Yammer, Source, and other blogs.
- Reaching out to our Staff Network Groups for their initial input in the recruitment campaign, but also sharing the adverts with their members.
- Creating online support material, accessible to all, to help with the assessment and selection process.

- The use of positive role models in the recruitment process and their stories and experiences as a CSS.

From this campaign, of the 80 CSS hires, 40 per cent were female and 58.8 per cent were BAME. This is higher than the existing CSS composition of 29 per cent female and 49 per cent BAME.

Leaver Survey

Understanding the reasons why employees leave the organisation is vital to us being able to retain key talent and scarce skills.

In September last year, we introduced an automatic leaver survey which was sent to all those leaving the organisation asking them to rank their top three reasons for leaving, then drilling down into these three reasons in more detail.

By far the most common response, with nearly 50 per cent of responses, cites lifestyle changes as a reason for leaving. This includes changing career, retirement or moving away from London. Just over 15 per cent chose 'training, development and career progression' as their main reason for leaving, with just under 10 per cent citing their role as their main reason.

Whilst this has provided good initial insight into the reasons why people leave the organisation, the initial response rate of 17 per cent of all leavers (175 responses received) does not yet allow us to identify key reasons by business area or by grade and target interventions to resolve any issues identified.

In the next quarter, we are reviewing the process underpinning the leaver survey, identifying ways we can increase the response rate to the survey, in particular for our senior manager leavers.

Graduate and Apprentice Update

Next week we will hold our first joint graduate and apprentice induction week at Pier Walk in North Greenwich. We will welcome 109 new apprentices across 23 different apprenticeship programmes, along with 32 graduates and 5 interns across 12 different schemes.

Both apprentices and graduates are essential for ensuring we have the right talent pipeline across

the organisation and ensuring that we reflect the city that we serve. The Commissioner, as part of his role as chair of STAT, has set us challenging targets for the diversity of our apprenticeship recruitment. We have made positive progress this year, with 36.7 per cent of our apprenticeship offers made being female, up from 20 per cent last year, and 36.7 per cent were from a BAME background, up from 35 per cent. We will also be welcoming further apprentices in February 2020 in our London Underground Engineering scheme. Of our graduate and internship offers, 24.3 per cent were female and 59.5 per cent were from a BAME background.

Emerging Leaders Programme

In April, applicants for the Emerging Leaders Programme were confirmed for 2019. This scheme is an optional third year of the General Management Graduate Scheme and gives those involved the required experience to roll off into a Band 3 management role.

Our third cohort of Emerging Leader graduates have been selected following a stringent selection process. These seven graduates will embark on an accelerated leadership development programme for one year further developing our talent pipeline. They will undertake placements in LU Operational Area Management, Housing Strategy, Vision Zero and Diversity, Inclusion & Talent.

Health & Wellbeing Strategy

The development of a new Health & Wellbeing Strategy will seek to introduce a more holistic and comprehensive approach to improving the health and wellbeing of our workforce. This will ensure we create a safer, more caring and compassionate organisation, with a workforce best equipped to deliver our business plan priorities.

This requires changing the view that wellbeing is the accountability of Occupational Health alone, to one where there is collective ownership, input, investment and action from across the organisation.

The strategy will examine the demographic health profile of the organisation, responding to existing health inequalities, and addressing the wider determinants that create good health and wellbeing.

A working group has been established and includes stakeholders from across the organisation, drawing down on expertise from Occupational Health, Facilities, Comms, Learning & Development, Diversity & Inclusion, Tech & Data, HR, Trade Unions and our Staff Network Groups.

We are also developing a health & wellbeing app for our employees, which will provide a personalised platform for employees to monitor and track their own health. It will also allow direct access for the promotion of initiatives, campaigns and signpost Occupational Health and other support services.

Rewarding & recognising our people

Reward Hub Improvements

In April 2019 we relaunched our existing discounts platform 'myTfL' as a broader 'Reward Hub' – an online portal where employees can access information and facilities for all aspects of their reward, recognition and benefits in a single location. The Reward Hub launched with a new supplier, Edenred, and provides access to retail discounts and gift vouchers as well as a fully online approach to 'salary sacrifice' benefits for Cycle to Work and Childcare Vouchers.

In June 2019 we successfully added online payslips to the portal so that all employees now access their payslip therefore removing the need to print and distribute paper payslips every period. In late autumn we will add an entirely new and innovative online recognition platform to the portal (see separate update below) and in 2020 will provide online Reward Statements for every employee.

Our aim with the Reward Hub is to transform how employees access their reward, recognition and benefits at TfL, providing a far better user experience whilst at the same time promoting the Total Reward offer to them far more effectively than we have done in the past. As such this is another initiative that is intended to support retention and improve employee engagement.

We are now working with Edenred to see how we can further enhance user experience and, in particular, deliver even greater value for our people from the discounts and benefit opportunities provided.

Recognition Platform

Through our Viewpoint survey, we have seen that effective recognition is one of the fundamental drivers of employee engagement. Whilst there are many forms of recognition utilised within our organisation, ranging from formal schemes to an informal 'thank you', TfL has for a number of years successfully operated a tiered formal recognition award framework called Make a Difference. Following a recent review that involved collating feedback from business areas, it became apparent that there were several improvements that could be made

that would increase employee trust and satisfaction in the framework. The key areas of feedback included making it less bureaucratic and more accessible, speeding up the time it takes to deliver recognition, and ensuring awards were more consistent given that there were 3 levels to choose from (bronze, silver and gold).

In December 2018 the People Leadership Group approved changes to the Make a Difference framework that addressed the main areas of feedback. The most notable of these was the decision to move to a single tier of formal recognition so that there could be no inconsistency in awards and in so doing put the focus on the giving of recognition rather than on the outputs of the scheme as in the level of award.

The changes to the framework were then planned to coincide with the implementation of a new online recognition platform as part of the wider Reward Hub. The online platform will ensure that everybody will be able to access the platform from either a personal or work device. The giving of recognition could potentially be near instantaneous and recognition collateral such as certificates can be produced locally for immediate presentation. We are planning for implementation by November 2019 but as with any technical solution we must ensure that it is robust and fully functioning before implementing.

Developing an Inclusive Workforce that is Representative of London

Action on Inclusion

Work has commenced on our new Diversity, Inclusion and Accessibility strategy; Action on Inclusion. This strategy follows on from the earlier Action on Equality report and demonstrates how we will to meet our Public Sector Equality Duty (Equality Act 2010). The strategy will also articulate how we will continue to deliver the Mayor's Transport Strategy objectives of mode shift, healthy streets and Vision Zero through an accessibility and inclusion lens.

Action on Inclusion will also make sure that our approach to our workforce diversity and inclusion issues is evidence based and learns from the latest developments in the sector including the use of behavioural science to more confidently establish 'what works.' Maturing our approach in this area will also include focusing on diversity of thought, background and experience as well as continuing to address issues of under representation, inequality and discrimination.

Leadership Foundation

At the start of the performance year, we concluded a feasibility study and gained Executive Committee approval to develop our Leadership Foundation proposals. Building a Leadership Foundation is our approach to professionalising leadership at TfL using experiential development, peer learning, coaching, work experience and focussing on solving real business priorities.

We have begun working with our supply chain to explore opportunities to build leadership capability together, with 02 Telefonica and Siemens on board, working with us to share mentoring opportunities, Intrepreneurial Challenges and work experience.

We are also trialling a mobile leadership development app called TalUpp. This will give our future leaders access to development material and activities on the go. A further 50 future leaders will be trialling the app in September.

Our Time

We have recently confirmed our second cohort of twelve women which will take part in the Our Time initiative. This initiative pairs high potential women with senior female and male employees from across the GLA family for a minimum of six months and helps to develop our diverse pipeline of well-prepared, confident and ambitious women that is essential to achieving gender parity in the workplace.

Delivering & embedding organisational change and modernisation

One of our key priorities for the year ahead is to support ongoing organisational change, through the support of our employee relations, business partner and employee communication teams.

The re-design of our organisation continues with formal consultation with Trade Unions progressing in ten business areas. These areas include: Investment Delivery Planning; Customers, Communication & City Planning; Finance; LU Network Delivery; LU Operational Upgrades; LU Asset Systems and Reliability; LU Asset Operations; Compliance Policing and On-Street Services; Public Transport Service Planning and Business Services.

We will also be looking to support the creation of a new Business Services function will achieve further cost reduction and revenue opportunities through simplification and structural integration across end-to-end processes. In building this new function, eight core processes have been assessed against industry benchmarks for customer centric delivery and continuous improvement.

We are working closely with our Trade Unions and our people to ensure we do all we can to avoid, reduce and mitigate redundancies, reduce the level of uncertainty through

change and to focus on the health and well being of our people.

Next steps

Developing our People Strategy

We are currently developing our new People Strategy which will set out our key people priorities over the life of the Business Plan. Earlier this year, the Executive Committee agreed our people vision; that TfL should be 'A great place to work for everyone'. Our People Strategy will bring the vision to life, making sure it runs through everything we do.

The strategy will sit above the individual year People Plan priorities and identify what people interventions, initiatives and priorities need to be in place to deliver the business plan over the next five years. The strategy will also align with our strategic people risks, ensuring that we anticipate and mitigate against people risks which will hinder our efforts to deliver our Business Plan objectives.

The strategy will be delivered to coincide with the publication of the business plan in December. A number of initial development workshops have taken place with key internal stakeholders from across HR. Initial findings from this work have identified four emerging themes that the strategy will focus on:

- Leadership
- Motivating our People
- Future Skills & Capability
- Creating a Diverse and Inclusive workforce

This work will continue through autumn and we will look to update the Panel on this work as it progresses.

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Safety, Sustainability and Human Resources Panel

Date: **4 September 2019**

Item: **Disability Roadmap**

This paper will be considered in public

1 Summary

1.1 Critical to delivering TfL's people vision of becoming "a great place to work for everyone", will be the delivery of our new Disability Roadmap. This paper provides an overview of the Roadmap, a planned programme of activity to help us become an organisation where disabled people are represented and included at all levels.

1.2 When we achieve this we know that we will be better equipped to deliver safe, affordable and accessible end-to-end journeys for our customers and to meet all the challenges set out in the Mayor's Transport Strategy (MTS) and our business plan.

1.3 The roadmap looks at actions needed to improve the recruitment, retention, promotion and inclusion of disabled people at all levels. It has been tailored to the specific issues identified as priorities by existing TfL employees and highlighted by our Diversity and Inclusion (D&I) Dashboard.

1.4 The exact deliverables and timelines are still being discussed and agreed across TfL and will be shared more fully with the Panel at a later stage.

2 Recommendation

2.1 **The Panel is asked to note the paper.**

3 Development

3.1 In April 2018, we launched the first version of our D&I Dashboards, providing D&I data and insight to our senior managers. Since then, these data driven dashboards have given us a much richer and insightful picture of employee outcomes and experience across the hire to retire employee life-cycle.

3.2 Actions taken as a result of the dashboards can be at a corporate, directorate or a local level. One example of a corporate response has been the development of a new Disability Roadmap. This was in recognition that on every measure of our dashboard our performance on disability was lower than our benchmark.

3.3 The Roadmap was developed in conjunction with disabled staff. We worked closely with our Staff Network Group for Disability to gain insight into real lived experiences, which directly informed how this plan will reduce the barriers faced by current and future disabled employees.

3.4 The development process also involved consultation with a range of internal and external stakeholders. We presented the Roadmap to the Trade Unions at the new TU D&I Forum. They identified the Reasonable Adjustments process as a priority area too. We will continue to work with the trade unions as this roadmap work progresses.

3.5 As well as the legal case for improving our management of disability issues, a business case is also clearly evident. A diverse workforce – which includes and harnesses the talents of disabled people - will enable us to better understand how to meet our passenger's needs and deliver an integrated and accessible transport network that London can depend on.

4 The Roadmap

4.1 According to our 2019 D&I Dashboard, 4.9% of employees have told us that they have a disability (which compares with 11 per cent of the economically active London population). While we know that there is a high level of under-reporting given both the lack of confidence people sometimes have in sharing this information and wider lack of awareness of how broad the legal definition of disability actually is, we still have more to do to recruit, retain and promote disabled people at TfL.

4.2 The Disability Roadmap has been designed to deliver change over a three year period. In 2018, activity primarily comprised of consultation, research, bench-marking and data analysis. Between 2019 and 2020 it will focus on project design, with 2020-2021 focusing on implementation and delivery.

4.3 As the Disability Roadmap is delivered we believe that we will see improvements to the disability measures across our employee lifecycle as measured on our D&I dashboard, including the Viewpoint responses from disabled staff

4.4 The Disability Roadmap outlines a wide range of more strategic and tactical solutions to make TfL more disability inclusive. This includes but is not limited to:

(a) Continuing to improve our disability data;

(b) Creating a new Reasonable Adjustments Process / Service;

(c) Investing in line manager capability aligned with our work on health and wellbeing;

(d) Refocusing of our employability schemes on disability;

(e) Ensuring our new leadership foundation is fully accessible for disabled staff and actively promoting and making more visible senior disabled people;

(f) Reviewing and updating TFL policies, procedures and design standards - where needed - to ensure inclusion of disabled staff; and

(g) Improving accessibility of internal information and communication.

5 The New Reasonable Adjustments Process / Service

5.1 The Disability Roadmap includes detailed mapping of what a good end-to-end Reasonable Adjustments Process should look like. We are conscious that considerable work is needed to get to this point and to ensure seamless management of adjustments across every stage of the employee life cycle.

5.2 Work is therefore already underway to scope a new Reasonable Adjustments Process and the options we have for delivering it . We have commissioned an external Reasonable Adjustment Expert to carry out this work and present options in a feasibility study.

6 Public Sector Bodies (2018) Web Accessibility Regulations

6.1 In September 2018, new regulations came into force, which mean we must make our website and mobile apps accessible. The Disability Roadmap further presents an opportunity for us to embed digital inclusion into our plans and ensure TfL is an accessible employer. Senior sponsors within TfL are supporting this work.

7 Disability Confident employer scheme

7.1 The Disability Confident scheme aims to help businesses successfully employ and retain disabled people and those with health conditions to reduce the disability employment gap.

7.2 We are one of 12,000 organisations signed up to the scheme, which has three levels; 1: Disability Confident Committed, 2: Disability Confident Employer, and 3: Disability Confident Leader.

7.3 We are currently a Level 2: Disability Confident Employer, which means we are recognised for trying to ensure disabled people get a fair chance at TfL. These commitments are integral to our policies, processes and practices. The Disability Roadmap presents the ideal opportunity for us to progress to a Level 3: Disability Confident Leader, meaning we will be leading by example, using best practice and championing disability inclusion within our sector and beyond.

8 Next Steps

8.1 Creating a pan-TfL Disability Roadmap steering group and agreeing clear deliverables, budgets and resources.

8.2 Completing the scoping work for the Reasonable Adjustment Process and review options to improve the end-to-end experiences where people need adjustments.

8.3 Continue working in partnership with key stakeholders to ensure the Roadmap is collaborative, and the principles of disability inclusion are embedded in practices across TfL’s business areas.

8.4 Provide regular updates to the Panel on our progress.

List of appendices to this report:

Appendix 1 – Disability Roadmap presentation

List of Background Papers:

None

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Appendix 1

Disability Roadmap

Diversity, Inclusion & Talent

TfL

EVERY JOURNEY MATTERS

Our Vision

- To work with our suppliers and partners to deliver an **inclusive and integrated transport network** that will help to secure the long-term economic sustainability of this amazing city.

- To achieve this we will need a **workforce with diversity** of thought, background and expertise.

- Plus **inclusive cultures**, behaviours and ways of working through which we can reap the benefits of diversity – improved safety, performance and cost-effectiveness

Context

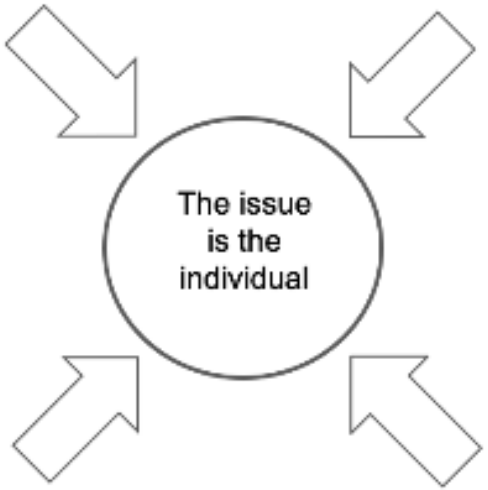
- People with physical and learning disabilities are amongst the most vulnerable and socially excluded in our society.
- They are also marginalised and excluded from the workplace.
- **7 million** people of working age in the UK have a disability or long-term health condition.
- Only **50%** of them are in work.
- Disabled people have an employment rate that is **30.1% lower** than non disabled people, often referred to as the **disability employment gap**.
- Barriers to employment include: **negative attitudes** and **discrimination**, inaccessible transport, lack of flexible working and poor awareness.
- A greater proportion of the workforce **will develop a health condition or disability** through **age, accidents, obesity and stress.**

- TfL data shows that there is an opportunity to improve the working environment for our disabled employees and recruitment.
- As a Disability confident employer, Transport for London is committed to supporting its disabled employees.
- The scheme aims to help businesses successfully employ and retain disabled people and those with health conditions to reduce the employment gap. These commitments are integral to our policies, processes and practices.
- We are aiming even higher to become a Disability Confident Leader where we will be assessed and put up for external challenge.

- Disability is one of the nine protected characteristics listed in **section 4 of the Equality Act (2010).**
- The Act defines a disabled person as someone who has a physical or mental impairment that has a **substantial** and **long-term** adverse effect on their ability to carry out normal day-to-day activities.

- The following types of discrimination are outlawed by the Equality Act:
  - **Direct discrimination**: treating a disabled employee less favourably than other employees.
  - **Indirect discrimination**: where there is a rule, policy or practice which seems to apply equally to everyone, but which actually puts disabled people at an unfair disadvantage, and which cannot be justified
  - **Discrimination arising from disability**: this occurs when a disabled person is treated less favourably because of something connected with their disability, and where the discrimination cannot be justified

Disability Models



Medical Model

Social Model

Transport for London supports the **social** model of disability which upholds that it is a disabled person's environment that limits their ability to complete a task.

Which means **we all** have a role to play in **reducing** the **barriers** faced by disabled people.

Reasonable Adjustments

- Reasonable adjustments are the linchpin of the law and **it is our legal duty** to make a reasonable adjustment where a disabled employee would be at a substantial disadvantage compared to non disabled.

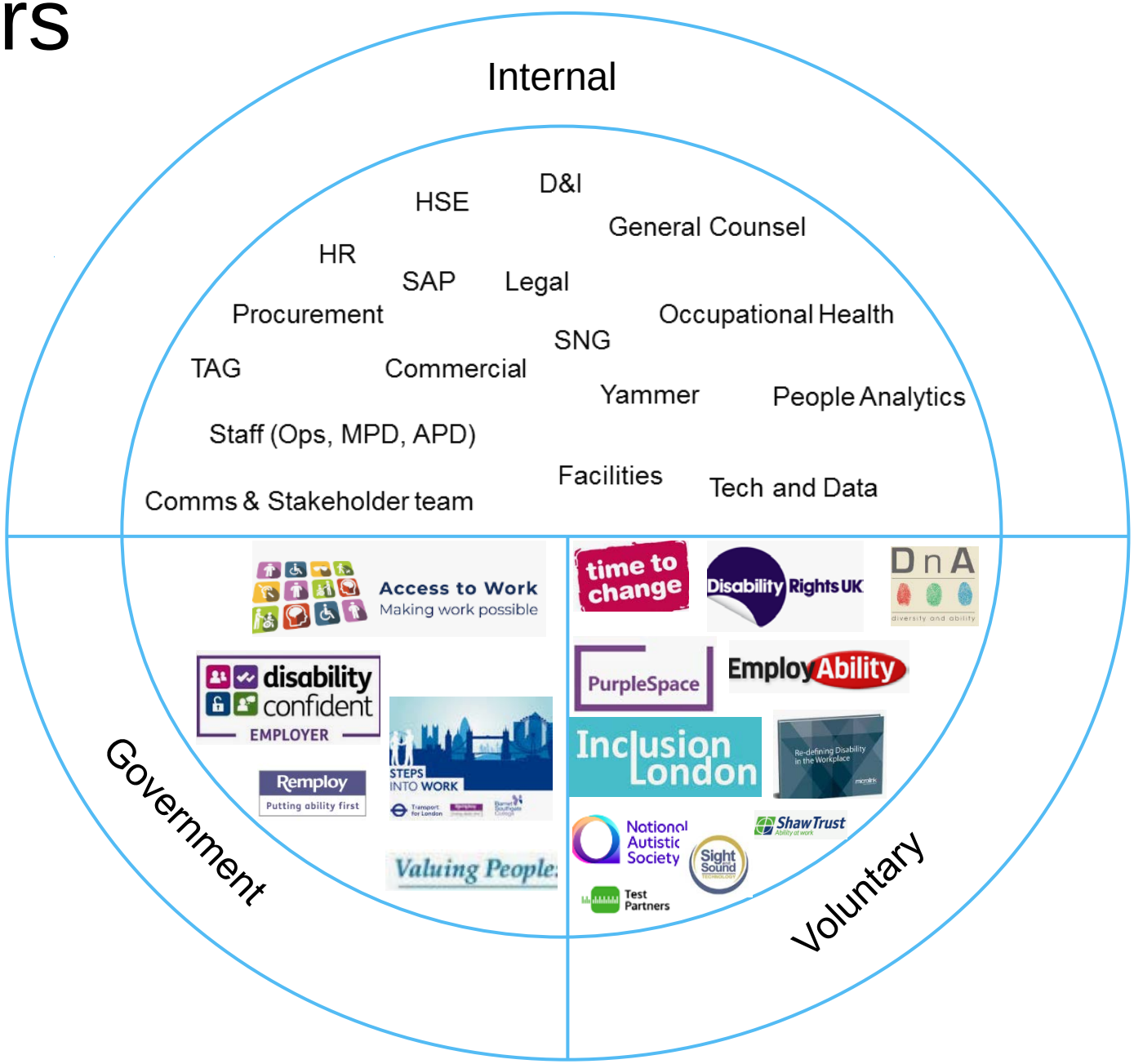
- There is a lack of consistency in how Reasonable Adjustments are currently applied across the organisation. Often confused with medical restrictions and reliant on Line Management judgement.

- Different people have different barriers. Adjustments may include:
  - Adapted duties or environment
  - Flexible working hours
  - Assistive technology.

- The adjustment should be effective in removing the barrier & practical to make.

- Access to Work can assist when costs are high.

Stakeholders



Disability Roadmap

Review and update TFL policies, procedures and design standards where needed to ensure inclusion of disabled staff

Create centralized adjustments budget

Improve line manager capability on disability

Procure new Reasonable Adjustments Service to better manage seamless end-to-end adjustments

Promote disability inclusive recruitment guidance and best practice inc management of any Reasonable adjustments.

Ensure closer collaboration between ER, Legal, OH, D&I and TAG on monitoring and learning lessons regarding disability inclusion esp reasonable adjustment provision

Explore further work experience and employment opportunities to build on the brilliant Steps Into Work

Improved career conversations with disabled staff to ensure that they are fully included in our talent management processes

Ensure ongoing and better engagement with disabled employees esp the SNG

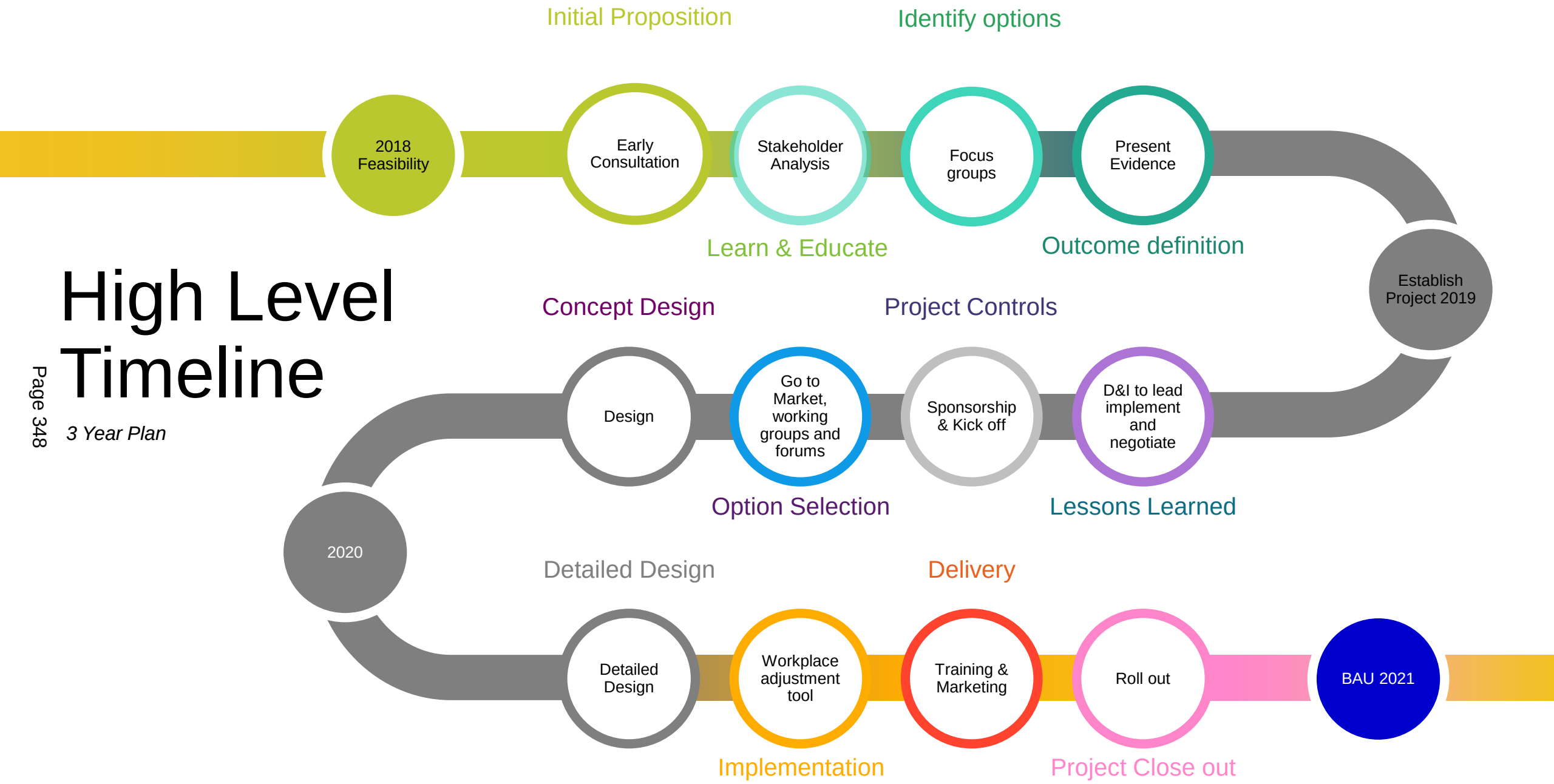
Improve accessibility of internal information and communication

Enable disability related leave in SAP

Ensure our new leadership foundation is fully accessible for disabled staff and actively promote senior disabled people,

High Level Timeline

3 Year Plan



Benefits

- ✓ Reduced time to complete adjustments process
- ✓ Reduced time on complaints, grievances & tribunals
- ✓ Reduced loss of staff
- ✓ Reduced absences
- ✓ Increased staff satisfaction & performance
- ✓ Reduction in number of staff sent to OH for triage
- ✓ Better declaration rates in SAP & Viewpoint
- ✓ Increase in staff attraction & retention

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Safety, Sustainability and Human Resources Panel

Date: **4 September 2019**

Item: **Active People Plan Update**

This paper will be considered in public

1 Purpose

1.1 The purpose of this paper is to provide the Panel with an overview of TfL's internal Active People Plan, which was drawn up to improve progress towards achieving the Mayor's Transport Strategy (MTS) target for 70 per cent of Londoners to achieve 20 minutes of physical activity per day by walking or cycling by 2041.

2 Recommendation

2.1 **The Panel is asked to note the paper.**

3 Executive Summary

3.1 The Active People Plan was drawn up in January 2019 to collate the short-term actions being taken by TfL that should help us to achieve the MTS target for 70 per cent of Londoners to achieve 20 minutes of active travel per day by 2041 (referred to as our Active People Target).

3.2 Unfortunately over recent years there has been a decline in the percentage of Londoners who report having achieved 20 minutes of active travel per day, with the most recent London Travel Demand Survey showing that only 30 per cent of Londoners are achieving this.

3.3 However, good progress is being made against each of the actions within the plan and it is hoped that this will lead to an improvement in performance of the Active People Target in the near future.

3.4 This paper sets out:

(a) the rationale for the Active People Target and the rationale for the creation of the Active People Plan to improve performance against the target; and

(b) an update on progress made in relation to each of the 11 actions within the plan and a discussion of key areas of focus going forwards.

4 Background

4.1 The Active People Plan was drawn up, in January 2019, to collate the short-term actions being taken by TfL that should help us to achieve the MTS target for 70 per cent of Londoners to achieve 20 minutes of active travel per day by 2041 (referred to as our Active People Target).

4.2 The health benefits from regular physical activity are substantial, and active travel is the easiest type of physical activity for people to engage in. Participation in active travel is far more equitable across a range of demographic groups that participation in sport.

4.3 The rationale for the Active People Target to be included within the MTS is two-fold. Firstly, the Mayor has an ambition to create a healthier, fairer city, and one of the key ambitions within his Health Inequalities Strategy is for all Londoners to be doing the physical activity they need to stay healthy. Secondly, in order to achieve our overall mode shift target, it is necessary for us to support Londoners to remain healthy throughout their lives so they can continue to travel by sustainable modes (as data shows that people with disabilities are less likely to walk, cycle or use public transport).

4.4 The MTS target of 20 minutes of active travel per day was chosen as it is in line with the UK Chief Medical Officer's (CMO) guidance that all adults should undertake 150 minutes of physical activity per week. If Londoners achieve 20 minutes of active travel per day then this will add up to a total of 140 minutes – close to the total recommended level. Asking Londoners to achieve this as a daily target of 20 minutes gives them something achievable to aim for, and can be further broken down into a message of 2 x 10 minute active journeys or journey stages.

4.5 We know what we need to do to enable people to be active through travel – we have to provide them with an attractive and accessible environment in which they are able to walk or cycle for shorter journeys and use public transport for longer journeys. Encouraging use of public transport is important because our analysis shows that people using public transport typically do between eight and 15 minutes of active travel a day, compared to less than one minute for those using a car. Half of all walking journeys in London are to or from public transport stations and stops.

4.6 Data from the Mini-Holland evaluation has shown that this approach works, with an average of an extra 44 minutes of active travel seen amongst those living in Mini-Holland areas compared with those living in non Mini-Holland outer London boroughs[1].

4.7 The MTS sets out the full suite of Healthy Streets Approach policies and activities that will deliver our Active People target by 2041. However in the short term, to turn around the trajectory on active people we need to apply these policies in a focussed way in order to reach our 'near market' of inactive people.

[1] The Mini-Holland programme awarded £30m each to three outer London boroughs – Enfield, Kingston and Waltham Forest – to help them create a network of cycle routes targeted at people who make short car journeys in outer London that could easily be cycled or walked instead.

4.8 The Active People Plan includes analysis which identifies the characteristics of our 'near market' population – those who are less likely to be meeting their 20 minutes per day of active travel, but who are more likely to be willing to change their behaviour in the short term. In the long-term we will need to support all Londoners to achieve behaviour change, however in the short term it is important that we focus on populations where there are a larger number of people making inactive trips and there is potential and propensity for those trips to be switched to active modes. In summary, our near market consists of:

(a) those aged 30-59;

(b) all genders, ethnicities, income levels;

(c) those living in inner London;

(d) car owners and non-car owners; and

(e) those in Transport Classification of Londoners (TCOL)[2] segments 'affordable transition', 'urban mobility', 'suburban moderation' and 'students and graduates'.

4.9 It is not just down to TfL to bring about this change, a wide range of stakeholders can and do support the shift to active lifestyles and we can coordinate our efforts to have more impact. However the Mayor and TfL have a pivotal role in setting pan London policy; convening and influencing, marketing and behaviour change, investing in London's transport system, shaping the new developments coming forward, working with boroughs on their transport policy and overseeing delivery of borough Local Implementation Plans (LIPs).

5 Current performance against the target

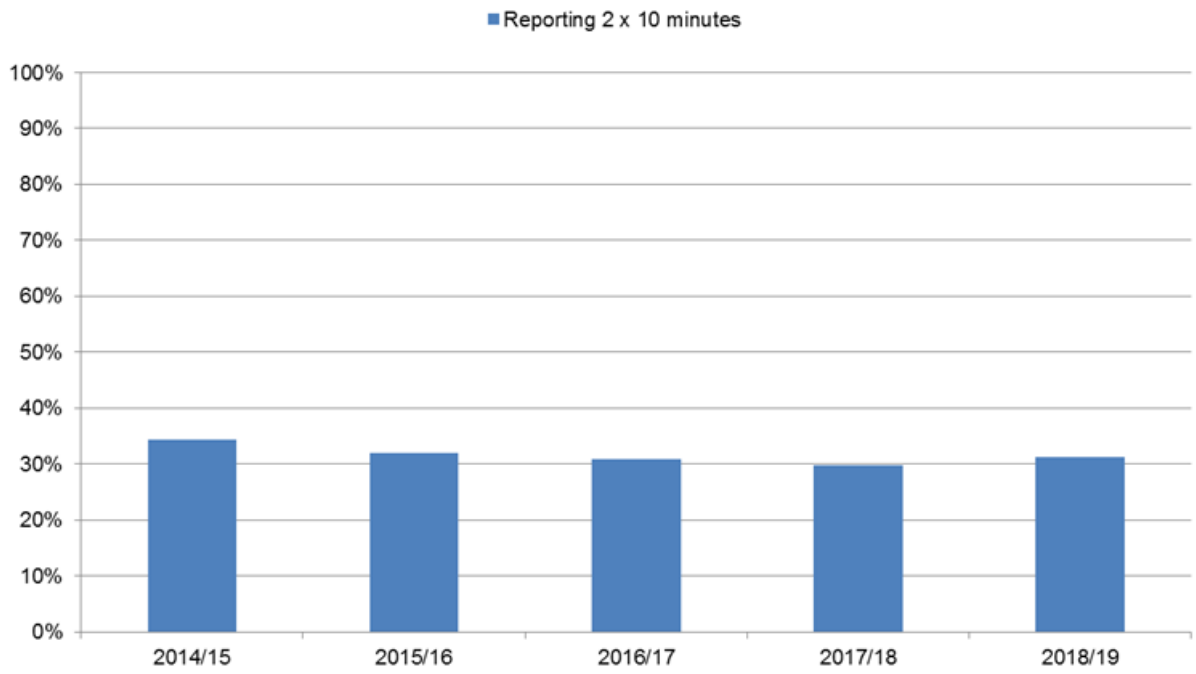
5.1 The MTS sets a target for Londoners to achieve 20 minutes of active travel per day, however the target is measured as 2 x 10 minutes to be in line with current CMO recommendations that physical activity should be conducted in bouts of 10 minutes or more[3].

5.2 Figure 1 below shows a slight annual decline in the proportion of Londoners achieving 2 x 10 minutes of active travel between 2014/15 and 2017/18. Despite this downward trend, the latest results show a slight increase between 2017/18 and 2018/19.

[2] The Transport Classification of Londoners (TCoL) is a multi-modal customer segmentation tool developed by TfL that has been designed to categorise Londoners on the basis of the travel choices they make, and the motivations for making those decisions.

[3] The evidence base behind the recommendations has been reviewed and recent evidence suggests that physical activity accumulated through bouts of *any* duration is likely to lead to health benefits. New guidance will be issued by the UK CMOs in September 2019, which may include a recommendation that minimum bout length (of least 10 mins) is no longer necessary. If the recommendations change then TfL will change to measuring 20 minutes of active travel comprised of bouts of any duration.

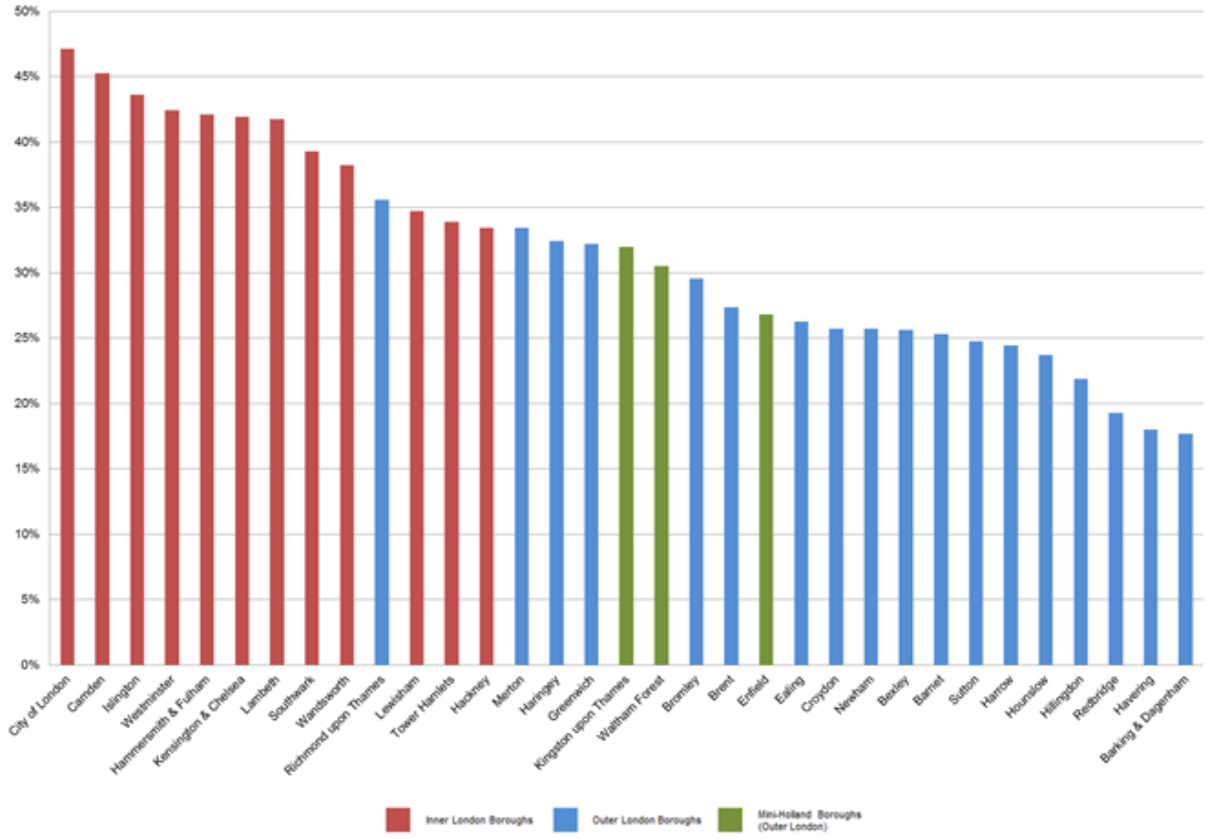
Figure 1. Proportion of Londoners reporting 2 x 10 minute of active travel



5.3 The trend observed in figure 1 is in line with overall trip rates, which did not decline for the first time in four years in 2018/19 (they are up by 0.6 per cent on 2017/18). The results do not necessarily mean we will continue to see an increase in 2 x 10 minutes of active travel as walking and cycling tend to fluctuate each year.

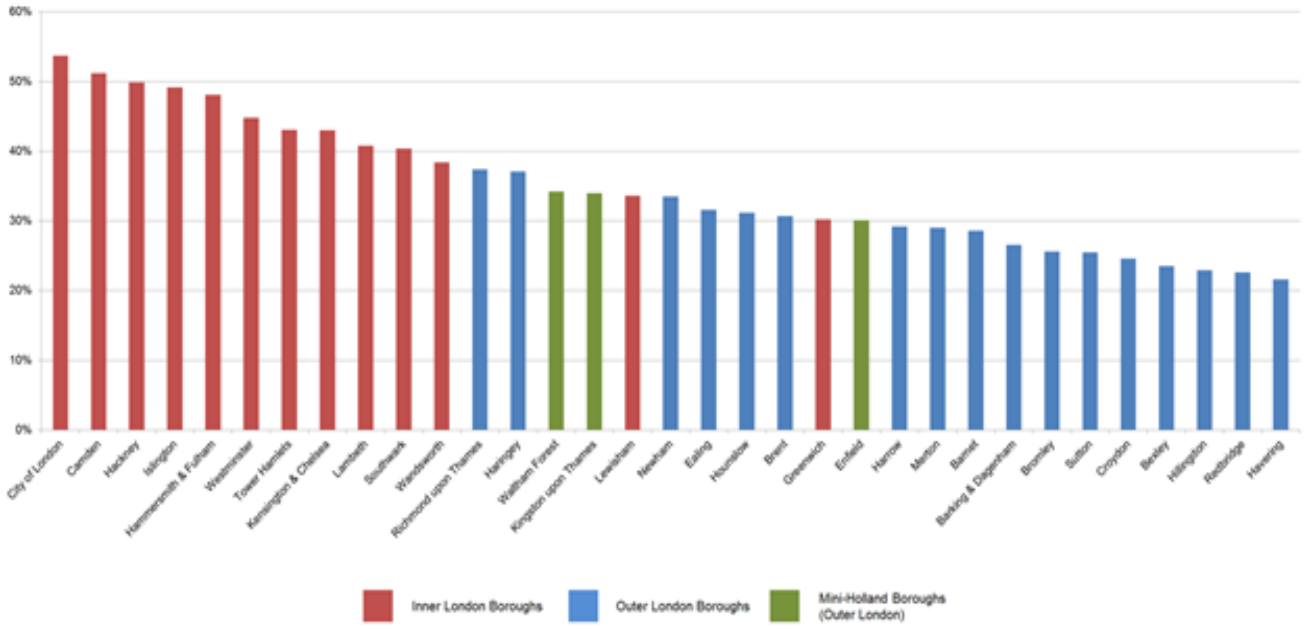
5.4 Figure 3 below shows how the proportion of people reporting 2 x 10 minutes of active travel differs by borough. Those living in inner London boroughs are more likely to report 2 x 10 minutes of active travel than those living in outer London boroughs, however there is a difference of over 10 percentage points between the best and worst performing inner London boroughs, and a difference of over 15 percentage points between the best and worst performing outer London boroughs.

Figure 3. Residents reporting 2 x 10 minute of active travel, by borough



5.5 The pattern of boroughs that perform well in the achievement of 2 x 10 minutes of active travel largely follows the same pattern of the boroughs that have a high active travel mode share, with inner London boroughs having higher active mode share than outer London boroughs (as seen in Figure 4, below). There are however some notable exceptions, for example Hackney is the borough with the third highest active mode share in London, but has the lowest proportion of people reporting achieving 2 x 10 minutes of active travel out of all the inner London boroughs. This suggests that one segment of the population is making many active travel trips rather than that the active travel trips are distributed evenly across the population. In contrast, Merton and Bromley have low active travel mode shares but are amongst the outer London boroughs with the highest number of people reporting 2 x 10 minutes of active travel – suggesting that the active travel is more evenly distributed across the population.

Figure 4. Active travel mode share by borough of residence



5.6 All boroughs have set active travel targets in their LIP consistent with the trajectories supplied by TfL for 2021 and 2041. However, there is considerable variation in the relative ambition of boroughs in supporting active travel, namely in terms of commitment to infrastructure improvements that would support more walking and cycling (e.g. implementing cycle lanes or redesigning road space to restrict motor traffic except through-access for cycling and walking).

5.7 Some highlights include:

(a) borough wide 20mph zones proposals for Merton and Richmond;

(b) Hounslow's Priority Cycle Network;

(c) development of a more extensive cycle network and healthy routes to schools in Bromley;

(d) focus on the greater uptake of STARS in Hillingdon;

(e) a range of measures to increase walking, cycling and public transport use driven by additional, more ambitious, targets for active travel trips in Hackney;

(f) greater priority for pedestrians and cyclists in the City; and

(g) detailed Walking and Cycling Action Plans from Camden, including the West End Project on Tottenham Court Road and Gower Street.

5.8 All boroughs do engage in behaviour change / training initiatives. Some boroughs have outlined targeted training / behaviour change measures in their LIPs, although not necessarily at the 'near market' of inactive people. For example, LB Brent has a proposal to provide cycle training specifically focused on faith schools and all female training.

5.9 A more detailed review will be undertaken to assess the current approach taken by individual boroughs in this area to identify potential opportunities for supporting improvement. This will inform our engagement with the boroughs and any future guidance to help them achieve their targets.

6 Update on actions within the Active People Plan

6.1 This section provides a summary of the 11 actions. Actions are highlighted to indicate whether they are on track (green), behind schedule (amber) or stalled (red). Currently 9 of the 11 actions are on track with 2 behind schedule and no stalled actions.

Understanding our audience better

6.2 We know which populations are inactive and more open to switching mode however we have not yet taken the next step of understanding what would prompt them to change mode and become active.

Action 1: Explore the need for qualitative research into the key triggers, most effective policies and activities and messages that would resonate most in order to fully understand how to get inactive people to increase their everyday active travel.
We have commissioned qualitative research with a sample of Londoners in two of the outer-London liveable neighbourhood areas (Ealing, Haringey and Waltham Forest). The research will involve understanding participants' current travel and activity behaviours, challenging them to try to achieve 20 minutes of active travel and documenting their travel and behaviours following the challenge. A subset of participants will be interviewed in-depth and will attend workshops to co-create potential solutions to address some of the barriers they faced in achieving the active travel challenge. Results are expected in early autumn.

Action 2: Develop future marketing and behaviour change activities to specifically resonate with our key audiences, in response to the findings from the research in Action 1. **Action 3:** Build a narrative that resonates with our inactive near market around the benefits of leaving the car behind (e.g. cost and time savings) and the negative impacts of driving for short trips (health, emissions).
Marketing campaigns for the current year on 'Summer of Active Travel'; Air Quality, and 'Two Fewer Car Journeys' are already planned for 2019/20, and are being delivered on schedule.

Getting more out of scheme delivery

6.3 The Healthy Streets approach is key to supporting inactive people to become active. Investments in making streets more inclusive and attractive for active travel are brought together into the Healthy Streets Portfolio, and our progress in delivering healthy streets is being monitored through the corporate scorecard measure of uplift in Healthy Streets Check for Designers (HSCD) scores. The London Assembly Healthy Streets Inquiry asked for greater ambition in delivering Healthy Streets and the following actions were therefore embedded in the Active People Plan.

Action 4: Include an objective to promote active travel by including walking, cycling and accessing public transport in the scope of all projects in the Healthy Streets Portfolio.

This has now been completed and should help to ensure sustainable modes are prioritised over general traffic and opportunities for improvements are not being missed.

Action 5: Require the Healthy Streets Check for Designers to be applied to all schemes that TfL funds directly, with a removal of the exemption previously given to schemes under £200,000 in value.

This change was made in April 2019, with schemes of all values now requiring a HSCD. This change has led to a large increase in the number of schemes that are expected undergo a HSCD in 2019/20 (increasing from 12 checks completed in 2018/19 to anticipated 60-70 checks to be completed in 2019/20).

12 checks have been completed as of the end of Period 4, and the weighted average uplift is currently 15 per cent.

Action 6: Support sponsors to monetise the health impacts of their projects in business cases using the World Health Organisation's Health and Economic Assessment Tool (HEAT) for walking and cycling.

A survey was conducted to understand how confident sponsors were in using the HEAT tool and found that 50 per cent of sponsors who had previously been trained were still not confident in using the tool.

A video tutorial has been produced to guide sponsors through the process of using the tool, along with additional materials to help with estimation of some of the input data required for the model.

Action 7: Supporting sponsors and designers to increase the ambition of Healthy Street designs by increasing engagement in and commitment to raising HSCD scores and sharing best practice of design features that are likely to have the greatest impact on scores.

Training has been developed and delivered to sponsors covering the Healthy Streets Approach, rationale for the use of the HSCD as well as the practical application of the check and examples of best practice. 91 per cent of sponsors have now been trained.

A best practice guide highlighting examples of design features that can contribute to increases in HSCD scores at relatively low cost is being developed, as a live-document that can be updated as new high-scoring schemes are identified.

The Business Case Development Manual will also be updated to encourage uplift in HSCD to be included as part of the strategic business case for schemes.

Providing support to boroughs

6.4 Healthy Streets training has been delivered to all boroughs and a Healthy Streets Approach is required in LIP and Liveable Neighbourhood submissions. Each borough has an 'Active People Target' within their LIP, however there is more that we could do to support boroughs to achieve this target including the provision of data and resource as outlined in actions 8 and 9 below.

Action 8: Sharing our analysis of inactive people with boroughs to support them to target local activities at their near market of inactive people

A workshop was delivered in April 2019 to borough officers from transport and public health teams. We shared our active people analysis and facilitated discussions on how boroughs could make better use of data, Healthy Streets Toolkits, partnership working and LIPs in order to make progress. A similar presentation was also delivered at the London Healthy Places Network meeting in June 2019.

We are developing an Active People Analysis Pack for circulation to boroughs which will include examples of the types of analysis that can be done using datasets within the City Planner Tool in order to prioritise areas for targeted activity. Following production of the analysis pack we will offer borough training in the autumn in the use of the data tools to those who would like additional support.

From September we will host a series of borough engagement events so that borough officers can stay up to date with the latest information on Healthy Streets as well as sharing best practice and networking.

Action 9: Training and supporting our new Healthy Streets Officers (HSOs) to enable the boroughs to target their behaviour change activities at the inactive population

The contract for the HSOs was awarded in July 2019 and it is expected that the officers will be in post in September 2019.

Officers will be trained in the Healthy Streets Approach as well as a focus on the Active People Target. Training will be delivered in September and will include the findings from our Active People research.

Maximise opportunities with central government and the health sector

6.5 With the Healthy Streets Approach providing the framework of the MTS, our transport strategy is recognised as a world first in also being a public health strategy. The NHS Long Term Plan has key ambitions around air quality and the workforce and there is a clear opportunity to link the agendas in the MTS with those of the NHS.

Action 10: Build relationships with NHS organisations to influence messages, services and facilities that staff and patients interface with in order to increase active travel amongst inactive groups.

We have engaged with the NHS Sustainable Development Unit, NHS Confederation of Chief Executives, NHS Employers and the Directors of the five London Sustainability and Transformation Partnerships – there is great appetite for joint working with TfL on both air quality and active travel.

We are planning an autumn engagement event (to be jointly hosted with Public Health England (PHE), NHS Sustainable Development Unit, NHS Confederation and NHS Employers) to allow key NHS stakeholders (from both workforce and estates teams) to come together and share best practice.

Develop a means of measuring inactive people becoming active within year

6.6 We currently use the London Travel Demand Survey to track year on year the changes in the active population. This gives us a robust long term overview of our progress towards achieving the MTS goal, however it does not provide more timely and local data that could be used to assess the impact of our initiatives and mould our programme in response to what is effective within the year.

Action 11: Work up a testable pilot using mobile phone GPS data to assess peoples' cumulative active travel minutes throughout the day.

We have explored a number of options for an app that would enable us to collect data to access people's active travel behaviour (including partnering with PHE's Active 10 app or commissioning our own bespoke app) and have concluded that in order for an app to be used long-term it needs to have a purpose other than physical activity tracking, as apps used for activity tracking tend to be used for short periods and then deleted.

We have therefore incorporated our requirement for active travel monitoring into the development of the TfL Go app. Current timescales are for piloting of the app in the autumn however it is possible that preliminary data may not be available for analysis until the end of the year.

7 Conclusion and Next Steps

7.1 We are committed to achieving the MTS Active People Target of 70 per cent of Londoners achieving 20 minutes of active travel each day by 2041 and the Active People Plan sets out the short-term actions that we are taking to improve progress towards this target.

7.2 The Plan has successfully brought together a range of stakeholders to focus on actions to reverse the current downward trend of this metric, and the actions within the plan are currently on track. However it is important to note that the actions will have a staged impact - we expect actions 1, 2 and 9 to impact activity levels in 2019/20; 4, 5, 6, 7 and 8 to impact in 2020-2022; and 3, 10 and 11 to impact from 2023 onwards.

7.3 While there is a range of policy actions within the MTS that will contribute to achieving both the Active People Target and the overall MTS mode shift target (for 80 per cent of journeys to be made by active or sustainable modes by 2041) it is important that these targets are seen as distinct and that sufficient focus and resource is invested in the actions that are needed to achieve the Active People Target.

7.4 The findings from the Action People Research, which is currently underway, will provide us with additional insights as to how we can better support those who are not currently achieving 20 minutes of active travel, and will help us to refine our Action Plan for 2020/2021.

List of appendices to this report:

None

List of background papers:

None

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Safety, Sustainability and Human Resources Panel

Date: **4 September 2019**

Item: **Workplace Parking Levies**

This paper will be considered in public

1 Purpose

1.1 The purpose of this paper is to brief the Panel on our work on Workplace Parking Levies (WPLs), which for the first time have been included in the Mayor's Transport Strategy (MTS).

2 Recommendation

2.1 **The Panel is asked to note the paper.**

3 Executive Summary

3.1 This paper sets out:

(a) the definition of WPLs and their legal basis;

(b) WPLs relevance to the MTS and how they could contribute to mode shift, active travel and public transport objectives;

(c) Our role as a supporter of WPL;

(d) an update on borough schemes; and

(e) issues for TfL as an authority that could implement WPL and also as an employer which could be subject to WPL in the future.

4 Background

4.1 A WPL is a licensing scheme whereby a charge is levied on employers for the regular occupation of parking places by employees, students and certain other people. Parking places for customers and non-regular visitors are not included. It is the choice of the employer whether to pass on the levy charge (in whole or part) to the employee. Revenue raised by the WPL must be used on borough projects and initiatives which are aligned with the objectives of the MTS.

4.2 In London, the Greater London Authority (GLA) Act 1999 (Schedule 24) has provided for WPLs to be implemented but these have not until now been advocated in the MTS. Proposal 23 of the current MTS states that boroughs can consider WPLs as part of local traffic reduction strategies, and the Local

Implementation Plan[1] 3 (LIP) guidance states that revenue raised in this way can be retained by the borough.

4.3 A WPL scheme can be established in London by:

(a) TfL;

(b) any London borough; or

(c) two or more boroughs jointly.

4.4 The Mayor can also direct a borough(s) to make a WPL scheme within its area or part. TfL or a London borough may also jointly promote a scheme with an authority with WPL powers outside London.

4.5 The Mayor may also issue statutory guidance to TfL and the boroughs about the exercise of their WPL functions (our work to develop this is described in section 6).

4.6 Revenue raised by the WPL must be spent by the authority on projects and initiatives that are in alignment with MTS objectives. Further detail is provided in Appendix 1.

4.7 Currently only one scheme operates in the UK, operated by Nottingham City Council and covering the whole borough area. See Appendix 2 for more detail on this scheme.

5 Potential impacts of WPLs

5.1 The Mayor's aim for 80 per cent of Londoners' trips to be on foot, cycle or by public transport by 2041 will require a concerted effort to encourage mode shift across all types of journey purpose.

5.2 Commuter journeys to work make up 12 per cent of all car trips in London, with over 750,000 people driving to work every day, a third of which are short trips (under 5km) that could be walked or cycled. Targeting commuting trips could therefore make a significant contribution to delivering the Mayor's mode share target, and the health, social and economic benefits that flow from it.

5.3 WPLs can help deliver mode shift in three ways:

(a) demand management: the increase in the total cost of driving to work (through an increase in parking charges);

(b) funding improvements to active travel and public transport; and

[1] The Local Implementation Plan (LIP) is a statutory document prepared under section 145 of The GLA Act (1999). Each London authority is required to prepare a LIP outlining its proposals for the implementation of the MTS in its area.

(c) long-term reduction in parking supply: as new development takes place, employers are more likely to minimise their parking as a response to an existing WPL.

5.4 Other potential benefits of WPL include:

(a) mode shift, which can lead to lead to air quality benefits. Outside London, the new Clean Air Zones programme is the main driver for local authorities' interest in WPLs;

(b) they can help to achieve Healthy Streets objectives and free up land for more appropriate uses including new development; and

(c) they can also act as a lever to other parking policies in the borough.

5.5 In order to implement a WPL effectively, boroughs also need to make other adjustments to parking policy, such as the introduction of Controlled Parking Zones to manage displacement. In this way a WPL can be part of a wider set of interventions to encourage a move away from private car use.

Revenue

5.6 All revenue raised by WPLs must be used to fund projects in line with the MTS. It is usually more acceptable to use a WPL to fund specific new infrastructure than a number of smaller interventions; however there is no legal requirement with regard to this.

5.7 It is the improvements to local transport networks, funded by the revenue raised from a WPL, that are most likely to deliver the MTS objectives by creating a viable public transport alternative to commuting by car.

6 TfL's role

6.1 Although we (on behalf of the Mayor) can establish WPL schemes itself, the Mayor has indicated that schemes should be borough-led, with revenues retained by the boroughs concerned. It is assumed, therefore, that the relevant WPL scheme will be promoted, made and consulted on by the relevant borough or boroughs. We would be subject to any WPL implemented in London where it provides employee parking, such as Underground depots.

6.2 All schemes and proposed use of the revenue generated will require the Mayor's approval. The Mayor has power to confirm (with or without modification) or reject a scheme. We will need to advise the Mayor on the acceptance or modification of schemes. Our role has been agreed as:

(a) providing support for the introduction of WPL schemes including drafting statutory Mayoral guidance, a model order to establish schemes, and procuring from Government the necessary secondary legislation to support implementation;

(b) co-ordinating the development of WPLs across London and ensuring that emerging schemes fit well with each other and with the overarching MTS goals; and

(c) supporting boroughs in developing and implementing WPLs. As well as supporting individual boroughs, we have a role in bringing together boroughs where a collaborative approach is indicated or to avoid conflicting schemes.

Co-ordination and Mayor's Guidance

6.3 No national Guidance on WPLs exists[2] and there is no Government intention to issue any, and the UK experience of them is fairly limited. We have, therefore, developed a draft Mayor's Guidance document to facilitate the development of WPLs in London which is capable of being approved by the Mayor. The Mayor's Guidance is statutory guidance from the Mayor to which boroughs must have regard. This Guidance ensures compliance with the relevant legislation while at the same time stating clearly what kind of schemes the Mayor would be minded to approve.

6.4 The Mayor's Guidance will mean that there is a single consistent set of expectations for schemes in London, both in terms of the characteristics of the scheme – for example not expecting a motorcycle exemption (in order to align with Vision Zero) and processes – for example requiring that a formal consultation and equality and business impact assessments are carried out.

6.5 Along with the cases made by individual boroughs, we will use compliance with the Mayor's Guidance as part of the process in making recommendations to the Mayor concerning the Mayoral approval role. Accompanying the Mayor's Guidance will be the model scheme order (MSO) which 'translates' the requirements and options set out in the Guidance into a scheme order that boroughs can use to develop and implement their own schemes.

6.6 We have sought to keep the Guidance as light-touch as possible, so that boroughs can develop schemes appropriate to local circumstances and borough objectives. Should a borough wish to depart from the "expectations" set out in the Guidance, it can make the case to the Mayor to do so. Further detail on the draft Guidance can be found in Appendix 3.

6.7 We are currently discussing this draft guidance document with relevant stakeholders. We presented the draft Guidance to London Councils' Transport & Environment Executive Sub Committee on 18 July 2019. We held a workshop for borough officers on 8 July 2019. We have also sought comments from statutory stakeholders and business representative groups. The feedback received from this engagement has informed a further draft of the Guidance which will be submitted to the Mayor for approval in early autumn 2019.

Supporting boroughs

6.8 Several boroughs identified WPLs as a potential traffic reduction measure in their LIP and it is also understood that at least one borough is considering WPLs in their Liveable Neighbourhoods bid. Two schemes to note are:

[2] A draft was prepared by the DfT in anticipation of the Nottingham scheme, but never published.

LB Hounslow – it has the most well-progressed proposal and it has already undertaken informal consultation in late 2018 and completed an initial feasibility study. In September 2019 it will be seeking Cabinet approval to develop a business case. The WPL would apply to an area within the Great West Corridor Opportunity Area, with the revenue contributing to the construction of a new station at Brentford, which would link to the Elizabeth Line at Southall station ('the Southall Link'). It could also contribute to the West London Orbital, complementary bus services and walking and cycling links, especially if the scheme applied to a wider area.

LB Camden – we have match-funded a parking survey in Camden. The borough is interested in a WPL as a means of achieving further mode shift and paying for a range of Healthy Streets-type interventions. Initial results of the parking survey are expected at the end of the summer.

6.9 We have encouraged boroughs to engage with us early on in the process so that we can retain an overview of emerging schemes and avoid conflicting objectives or approaches.

6.10 As well as the Mayor's Guidance and MSO, we have supported boroughs individually by providing help with procuring parking surveys (which are a necessary first step in developing a scheme), data analysis (for example on commuting patterns) and evidence around the potential impacts of a scheme. We have also met with councillors on request.

6.11 During the rest of this year we will be finalising various resources for boroughs and making them freely available on our website. We will also continue to offer individual support.

6.12 We have also met with a group of south London borough officers who are interested in exploring a sub-regional scheme, subject to the results of a parking survey and political endorsement.

7 Next steps

7.1 We will be formally issuing the Mayor's Guidance in early autumn, subject to Mayoral approval. In the meantime we will be making resources related to WPLs available on our website and will continue to respond to boroughs' requests for support in developing individual schemes. As and when schemes reach a stage where they are submitted to the Mayor for approval, we will advise the Mayor on whether to accept or modify schemes.

List of appendices to this report:

Appendix 1: Legal and regulatory framework
Appendix 2: Nottingham WPL
Appendix 3: Information on draft Guidance

List of background papers:

None

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Appendix 1: Legal and regulatory framework

WPLs are legally established in an order (a “Scheme Order”) made by the licensing authority that sets out the details of the particular WPL scheme and gives it legal effect. The body – TfL or borough(s) – establishing a WPL is known as the “licensing authority”. It makes WPL scheme orders that after consultation must be approved by the Mayor (with or without modification). The Secretary of State for Transport also has a role in approving the revenue plans associated with WPL schemes. TfL’s discussions with DfT have indicated that they would expect the Mayor to lead on this in practice.

We have prepared a model scheme order (“MSO”) for use by the boroughs as they develop and consult on schemes commissioned. This has been commissioned from the same legal firm that drafted Nottingham’s order.

Developing the MSO will save borough legal costs, avoid duplication, help to ensure that schemes are in conformity with Mayoral objectives and to provide a degree of uniformity of approach across London.

As previous Mayors’ transport strategies did not advocate WPL schemes (concentrating instead on congestion charging schemes) there was never any real prospect of a scheme materialising. Thus the Government never put in place for London the underpinning secondary legislation that the GLA Act 1999 originally left to be fleshed-out in regulations.

Now that WPL schemes are likely to be made it is necessary to secure new regulations from Government to allow the operation of WPLs in London.

To save time and administrative resource TfL commissioned the same legal firm that developed the MSO to draft regulations that the Government could use as a basis for their own regulations. The regulations themselves need to be made by the Ministry of Justice and DfT and are likely to take around a year to enact. We have been in regular contact with the DfT, which has indicated its willingness to progress these regulations once a slot in the parliamentary timetable can be found, however changes within Government have meant that this is not yet secured.

The current lack of these regulations is not a hindrance to the development of individual schemes proposals – which in any case are likely to take 2-3 years – but they will be necessary for their effective implementation once made and confirmed.

Two WPL schemes cannot operate in the same location (but a WPL can operate in an area where there is also a road user charging scheme such as the Congestion Charge or Ultra Low Emission Zone). The duration of a WPL needs to be set at the start and would be expected to be at least 25 years in order to have a worthwhile impact.

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Appendix 2: Nottingham WPL

The Nottingham WPL has been running for seven years and has so far raised £64m which has helped to pay for a tram network, electric buses and refurbishment of the main station. The overall impact of these interventions led to an increase in public transport mode share in Nottingham; in autumn 2015 it rose to over 40 per cent in the AM peak for the first time[1].

The current levy is £415 per year. There are 2,100 licensed businesses in Nottingham however only 850 of these are liable to pay the WPL (owing to a 10 place threshold for liable parking places, intended to help small businesses). Eight out of ten employers pass the charge on to employees.

Some employers have taken advantage of the WPL to re-shape their parking management (freeing up land for other uses) and employee travel. The university and local authority both have their own parking charges structure which passes on WPL in a tailored way. We should expect a similar response in London.

[1] https://www.fleetnews.co.uk/fleet-management/workplace-parking-levies

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Appendix 3: Information on draft Guidance

The following requirements are specified in the draft Guidance:

(a) **Minimum charge level.** We are seeking views on whether there should be a London-wide minimum charge level or whether there should be a 'tiered' approach in which there is a different minimum charge level for inner and outer London. We need to set this at a level that will help to discourage 'undercutting' behaviour where boroughs seek to compete with each other and provide assurance to businesses. The proposed level is based on factors including the average cost of the daily bus or tram commute; demand impacts; average on-street parking charges in London and Nottingham's charge.

(b) A **100 per cent Blue Badge discount** in order to mitigate adverse impacts on people with fewer options for travel

(c) **Exemptions for 'operationally necessary' vehicles/users**. This includes for example fleet and delivery vehicles and business customers. We have also explicitly stated an Emergency Services exemption, although these are not strictly in scope by virtue of not being commuter vehicles in the first place.

(d) **Boroughs to set own PCN levels** but to set at a level which reflects the WPL.

(e) **Formal consultation on the scheme and production of documents including impact assessments, Business Case.** As stated above, the onus will be on the promoting authority to justify the WPL to the Mayor and to its residents and affected businesses. Therefore it is appropriate to specify formal processes for consultation on the proposed scheme.

The Nottingham scheme has a 10-place threshold. This was developed at the time to meet the authority's objective of supporting small businesses; it also improved the scheme's acceptability and helps to manage operational costs. We have included an option in the MSO to adopt this type of approach, setting the threshold as appropriate for the particular scheme. Nottingham also provides a discount for frontline NHS workers, which we have not specified as a requirement or expectation in London, although individual boroughs may choose to make the case for it depending on their circumstances.

We have also included an option for a time-limited electric vehicle discount. Boroughs can develop other discounts as appropriate to their scheme.

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Safety, Sustainability and Human Resources Panel

Date: **4 September 2019**

Item: **Strategic Risk Update - TfL's Environmental Impact (SR14)**

This paper will be considered in public

1 Purpose

1.1 The purpose of this paper is to update the Panel on the status of Strategic Risk SR14 – TfL's Environmental Impact, in line with TfL's Enterprise Risk Management Framework.

1.2 A paper is included on Part 2 of the agenda, which contains exempt supplemental information pertaining to the strategic risk 'deep dive'. The information is exempt by virtue of paragraph 3 of Schedule 12A of the Local Government Act 1972 in that it contains information relating to the business and financial affairs of TfL that is commercially sensitive and likely to prejudice TfL's commercial position. Any discussion of that exempt information must take place after the press and public have been excluded from this meeting.

2 Recommendation

2.1 **The Panel is asked to note the paper**.

3 Introduction

3.1 Strategic Risk 14 (SR14) – TfL's environmental impact – describes the risk of a failure to meet any of TfL's public commitments, or legal requirements, on environmental issues. This is principally focused on air quality and carbon reduction initiatives; however it also includes issues such as biodiversity and sustainable drainage issues.

3.2 Key environmental commitments in the Mayor's Transport Strategy (MTS) are summarised in the below table. We also support several London Environment Strategy (LES) commitments as part of the GLA Group (summarised in the Leading by Example Chapter of the LES), and have legal compliance obligations such as management of noise levels.

MTS commitment	Status
Deliver Ultra Low Emission Zone (ULEZ) in central London in 2019, strengthen Low Emission Zone standards in 2020, expand ULEZ to the North/South Circular roads in 2021	On track

MTS commitment	Status
All TfL buses Euro VI compliant by October 2020; TfL bus fleet to emit zero exhaust emissions by 2037 at the latest	On track
45% reduction in NOx emissions from taxis by 2020	Action required
Overall emissions reductions from London's transport by 2041:	
• 72 per cent reduction in road and rail CO_2	Action required
• 94 per cent reduction in road NO_x	On track
• 53 per cent reduction in road transport $PM_{2.5}$ / 45 per cent reduction in PM_{10}	Action required
Meeting a 60 per cent reduction in TfL Corporate CO_2 emissions on 1990 levels by 2025	On track
Aim for all TfL-controlled rail services to be zero carbon by 2030	Action required
Ensure transport schemes deliver a net gain in biodiversity	Action required
Increase street tree numbers on the TLRN by 1 per cent every year between 2016 and 2025	Action required
Create Sustainable Drainage Systems (SuDS) to enable an additional effective surface area of 50,000 m^2 to first drain into SuDS rather than conventional drains and sewers.	Action required
Climate change adaptation – *see SR15 review*	Action required

3.3 The impacts of failing to meet our environmental commitments include: legal or financial penalties; health impacts; and reputational damage.

4 Causes

4.1 The following section sets out the possible causes that could contribute towards TfL failing to meet its environmental commitments and legal requirements in air quality, carbon and green infrastructure.

4.2 The probability of the risk impacting will vary by cause, but is assessed overall as high (50 per cent – 80 per cent) due to the requirement for clear actions to meet medium term emissions trajectories.

4.3 External events may also have an impact on TfL's commitments. For example, Heathrow expansion or failure to achieve NO_x emissions reductions from non-transport sources, may lead to increased pressure on TfL to further accelerate reductions in transport emissions.

Air quality

4.4 Existing measures to reduce NO_x emissions from road transport – e.g. strengthening LEZ / expanding ULEZ, bus retrofit / replacement, rapid charging infrastructure – are all on track. However further measures are required to meet emissions trajectories set out in the MTS in the medium term, in particular beyond the 2021 expansion of the ULEZ scheme. Vehicle tyre and brake wear forms an increasingly large proportion of road transport particulate matter emissions; reductions in road vehicle km and mode shift to walking, cycling and public transport are therefore required to meet emissions targets. Reductions in road transport CO_2 emissions are similarly reliant on meeting the MTS mode share goal.

Carbon

4.5 Current forecasts indicate that TfL will meet reductions in its corporate CO_2 emissions required by the LES; however this is dependent on the decarbonisation of grid electricity. Measures are also required to meet the LES ambition for TfL rail services to be zero carbon, and support manifesto commitments, such as solar generation and utilisation of London Underground waste heat.

4.6 The UK's adoption of a new national zero carbon target by 2050 may lead to the revision of London targets impacting on TfL. This may also increase scrutiny on carbon emissions associated with new transport infrastructure.

Green infrastructure

4.7 The MTS commits TfL to deliver improvements to green infrastructure and biodiversity on London's transport network. Current data suggests that we could still meet the cumulative target for street tree planting, but low levels of planting in 17/18 puts this at risk. Whilst Sustainable Drainage Systems (SuDS) are being implemented across the TfL estate, such as green roofs, most of these will not contribute to the MTS target which applies to highways. Biodiversity net gain is being trialled across several projects and a review of these pilots is currently being conducted to inform future changes to the biodiversity net gain project toolkit and training.

5 Impacts

5.1 The scale of impacts is assessed as high, primarily due to the likely cost and regulatory impact of failure to meet air quality and/or CO_2 emissions targets. Any requirement for short term or unplanned measures to reduce emissions in the event of planned activities failing to deliver stated improvements would represent a significant cost pressure.

5.2 Public and stakeholder perception of TfL's environmental responsibilities are increasing with greater levels of coverage and public opinion on issues, for example recent protests on climate change by Extinction Rebellion or campaigns to reduce levels of single use plastic. London's probable hosting of the United Nations Climate Change Conference (COP26) in 2020 is likely to further increase scrutiny on emissions reduction actions. This may lead to increased reputational damage if commitments are not met.

6 Mitigation and Control

6.1 The Air Quality and Environment portfolio represents the principal capital portfolio to deliver investment in environmental improvement.

6.2 Work supporting the TfL Energy and Carbon Reduction Strategy sets out and monitors the actions required to meet TfL's CO_2 emissions commitments. Prioritised recommendations for investment to meet TfL's energy and carbon commitments have been submitted to the 2019/20 business planning round as part of the most recent update on this.

6.3 Better coordination and monitoring is required to ensure successful delivery of other environmental policy priorities, such as green infrastructure. The proposed development of a corporate environmental strategy later this year will aim to include clear coordination and tracking of all environmental commitments.

6.4 Processes to ensure that TfL's wider activities support environmental commitments are embedded in Working at TfL, Pathway, engineering standards and procurement documentation. Strengthened coordination and governance is required to support these in practice.

6.5 Beyond the expansion of ULEZ in 2021, medium term emissions trajectories are highly dependent on achieving road vehicle km reductions. Achieving these is therefore dependent on meeting the MTS mode share targets, including reduction in car traffic during the 2020s.

7 Summary

7.1 The current assessment of the level of risk and mitigation measures in place is considered appropriate.

List of appendices:

A paper containing exempt supplemental information is included on Part 2 of the agenda.

List of background papers:

None

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Safety, Sustainability and Human Resources Panel

Date: **4 September 2019**

Item: **Strategic Risk Update – Climate Change and Extreme Weather (SR15)**

This paper will be considered in public

1 Summary

1.1 The purpose of this paper is to update the Panel on the management of Strategic Risk 15, climate change and extreme weather, in line with TfL's Enterprise Risk Management Framework.

1.2 A paper is included on Part 2 of the agenda, which contains exempt supplemental information pertaining to the strategic risk 'deep dive'. The information is exempt by virtue of paragraph 3 of Schedule 12A of the Local Government Act 1972 in that it contains information relating to the business and financial affairs of TfL that is commercially sensitive and likely to prejudice TfL's commercial position. Any discussion of that exempt information must take place after the press and public have been excluded from this meeting.

2 Recommendation

2.1 **The Panel is asked to note the paper.**

3 Background

3.1 The latest climate change projections suggest that the UK will experience warmer, wetter winters and hotter, drier summers. There will also be an increased frequency of severe weather events, such as the 2018 'Beast from the East', subsequent summer heatwave, and this summer's combination of heatwaves and heavy rainfall. This will have significant impacts on both infrastructure and people.

3.2 Severe weather events already affect our ability to deliver a safe, reliable, sustainable and efficient transport network. For example:

(a) heatwaves require train speed restrictions to reduce impacts to the track (this was necessary at the end of July this year): this affects service reliability;

(b) flooding can damage our road and rail networks, as well as making conditions less safe for the public and our staff: this affects our maintenance budgets and our Vision Zero target; and

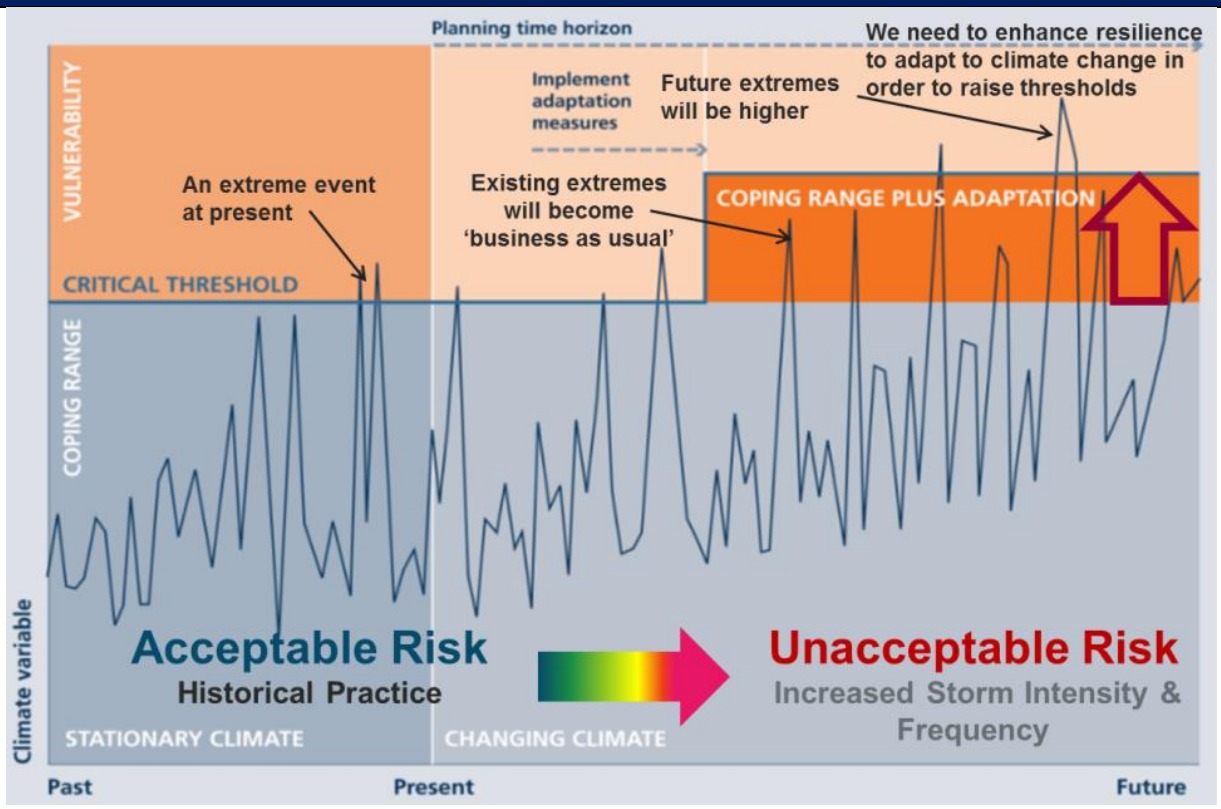
(c) drought can destabilise embankments and damage road surfaces: this affects our maintenance budgets and service reliability.

Using adaptation to enhance resilience

3.3 Currently, we are good at preparing for, responding to, and recovering from severe weather events (known as resilience). For example, the 54321 process (a systematic and structured approach to the management of severe weather across London Underground and Surface) helped ensure June's unseasonably heavy rainfall resulted in the most serious incident being a short closure of Regent's Park station. However, as the frequency of these events increases over time, our ability to recover quickly from their impacts could decline.

3.4 Adaptation measures, such as flood defences and reducing our water usage, reduce (or even avoid) the impact of severe weather events in the first place, avoiding exceeding critical operational thresholds, and making it quicker and more cost-effective to recover from them (See **Error! Reference source not found.** below). This will require a shift in the way we design and manage our assets over the longer-term (e.g., ensuring that Sponsors' Requirements for projects include climate change adaptation).

Figure 1: Climate change will amplify risk – adaptation will increasingly be necessary to reduce that risk



3.5 To identify the most cost-effective adaptation measures, it is necessary to:

(a) first identify how severe weather events impact current operations (including identifying thresholds for infrastructure / service failure). For example, between 2006 and 2019, Network Rail identified a 2-3 per cent performance drop on adverse weather days, with weather issues costing an average of £50-100m per year in delays – **we are currently at this stage in the process, explored in the following sections;**

(b) then model how impacts will change over time, using the latest climate change projections and assessments of infrastructure age and condition; and

(c) finally, assess the costs of these future impacts, and determine whether there are cost-effective adaptation measures and when to deploy them.

Data requirements for adaptation

3.6 To identify how severe weather events impact current operations, we need accurate data.

3.7 We collect an enormous range of data from all parts of the organisation. However, our data collection systems are currently not designed to monitor impacts from severe weather events. As a result, whilst we are able to identify compelling correlations, we struggle to identify cause and effect. For example, we know that the frequency of London Underground delays increases with temperature but we cannot yet say for certain that heat is causing those delays.

3.8 It is also challenging to attribute recovery costs to a particular severe weather event. It also reduces our ability to make a compelling business case for adaptation. However, there are promising developments that can help us with this process. For example:

(a) we have begun a programme of research with academic partners to understand how current severe weather events impact on our operations;

(b) ISO 14090, *Adaptation to climate change – Principles, requirements and guidelines*, was published in June 2019. This is the world's first international standard for integrating adaptation into organisational processes, and its implementation enables users to directly contribute to the United Nations' Sustainable Development Goal on climate action. We are exploring whether this could be usefully applied to our operations; and

(c) Kent County Council will release software in late 2019 that allows visual representation of the efficacy of different interventions at different times. Together with the results of our research programme, this could help identify the most cost-effective approach for adapting to a climate change impact.

Assessing and reporting on risk

3.9 We are responding to the third round of Defra's Adaptation Reporting Power (ARP3) at the end of 2021. As part of this, an assessment of how we embed climate change in our risk management process is needed. Our Active Risk Management (ARM) system is out of date and not all teams' risk assessments feed into the ARM system. In addition there is inconsistency in risk classification (whether in terms of level in the Enterprise Risk Management hierarchy, or in terms of issues such as 'environment' or 'climate change'), making it more difficult to trace how an issue is being addressed across the organisation.

3.10 To address this we will work with the Enterprise Risk Management team and risk owners across the business to plug this gap. This will also increase transparency in our assessment and reporting of risk and could be an exemplar for the transport sector.

3.11 In the meantime, the 'Causes' and 'Consequences' sections of Strategic Risk 15 have been updated, based on the latest climate change projections and feedback from a range of stakeholders across the organisation.

3.12 Further updates to the 'Risk assessment', 'Controls' and 'Actions' sections of Strategic Risk 15 will be made in autumn 2019. This will follow consultation with key stakeholders across the business, such as risk owners and asset managers, in collaboration with the Enterprise Risk Management team.

3.13 In addition to ARP3, the Task Force on Climate-related Financial Disclosure (TCFD) also requires an assessment of climate-related risks. Whilst aimed primarily at investors, TCFD's relevance to TfL relates to our bus and rail operating companies. With increasing investor and insurance sector concerns about exposure to climate risks, a robust and quantitative risk assessment and management process will become more important and potentially advantageous. For example, the London Underground Comprehensive Review of Flood Risk study resulted in a significant (approximately 30 per cent) reduction in our insurance premiums.

4 Summary

4.1 The current assessment of the causes and consequences of climate change is appropriate. The level of risk and mitigation measures will be comprehensively reviewed by stakeholders across the business in autumn 2019.

List of appendices:

A paper containing exempt supplemental information is included on Part 2 of the agenda.

List of background papers:

None

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Safety, Sustainability and Human Resources Panel

Date: **4 September 2019**

Item: **Transformation Programme Update**

This paper will be considered in public

1 Summary

1.1 This paper provides an update on the Transformation Programme.

2 Recommendation

2.1 **The Panel is asked to note the paper.**

3 Background

3.1 The changes we are proposing are intended to reduce operating costs and build our capability to raise revenue to enable delivery of the Business Plan. This includes further proposals to reduce back and middle office costs over the next three years by 30 per cent.

4 Current Activity

4.1 The re-design of our organisation continues with formal consultation with Trade Unions progressing in ten business areas. These areas include: Investment Delivery Planning; Customers, Communication and City Planning; Finance; London Underground (LU) Network Delivery; LU Operational Upgrades; LU Asset Systems and Reliability; LU Asset Operations; Compliance Policing and On-Street Services; Public Transport Service Planning and Business Services.

4.2 The creation of a new Business Services function will achieve further cost reduction and revenue opportunities through simplification and structural integration across end-to-end processes. In building this new function, eight core processes have been assessed against industry benchmarks for customer centric delivery and continuous improvement. This is a common model in many organisations. Initially providing HR and Finance transactional services across TfL (e.g. payroll, accounts payable etc.), our Business Services function will be structured to provide the option for further transactional services to be added to it over time.

4.3 A further phase of organisational change, subject to Executive Committee approval, could launch in autumn 2019.

4.4 Alongside this organisational re-design we are also supporting a shared services workstream for the GLA, This is looking at opportunities to share HR, IT and Facilities Management services with other members of the GLA Group. This

would compliment services that are currently provided by the TfL Procurement & Supply Chain team to the wider GLA Group.

4.5 Our work to date has focussed on examining individual business areas. In doing so, we have made significant progress in reducing our operating costs. With our changing financial landscape, we must maintain momentum both in achieving our savings plan and continuing to modernise our organisation. We will now take a more process-driven approach to organisational re-design. This will ensure that we only undertake activities which add value; there are single points of accountability across the organisation; and we embed agile processes and ways of working.

List of appendices:

None

List of Background Papers:

None

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Safety, Sustainabiliy and Human Resources Panel

Date: **4 September 2019**

Item: **Members' Suggestions for Future Discussion Items**

This paper will be considered in public

1 Summary

1.1 This paper presents the current forward programme for the Panel and explains how this is put together. Members are invited to suggest additional future discussion items.

2 Recommendation

2.1 **The Panel is asked to note the forward programme and invited to raise any suggestions for future discussion items.**

3 Forward Plan Development

3.1 The Board and its Committees and Panels have forward plans. The content of the plans arise from a number of sources:

(a) Standing items for each meeting: Minutes; Matters Arising and Actions List; and any regular quarterly reports. For this Panel these are the Health, Safety and Environment Quarterly Report and the Human Resources Quarterly Report.

(b) Regular items which are for review and approval or noting such as the Health, Safety and Environment Annual Report.

(c) Items requested by Members: The Deputy Chair of TfL and the Chair of this Panel will regularly review the forward plan and may suggest items. Other items will arise out of actions from previous meetings (including meetings of the Board or other Committees and Panels) and any issues suggested under this agenda item.

4 Current Plan

4.1 The current plan is attached as Appendix 1. Like all plans, it is a snapshot in time and items may be added, removed or deferred to a later date.

List of appendices to this report:

Appendix 1: Safety, Sustainability and Human Resources Panel Plan.

List of Background Papers:

None

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Safety, Sustainability and Human Resources Panel Forward Planner 2019/20

Membership: Kay Carberry CBE, Dr Nina Skorupska CBE (Vice Chair), Bronwen Handyside, Dr Mee Ling Ng OBE and Mark Phillips .

Abbreviations: Managing Director (MD), Customers, Communication and Technology (CCT), London Underground (LU), Surface Transport (ST), CPO (Chief People Officer), D (Director), DIT (Diversity, Inclusion & Talent) and HSE (Health, Safety & Environment)

13 November 2019		
Quarterly Health, Safety and Environment Performance Reports (to include resilience, assurance and compliance issues)	D HSE	To note
Review of CIRAS Report and Themes	D HSE	To note.
Workplace Violence Strategy Update	D HSE	Annual review to note
Platform Train Interface Update	D HSE	To note
Human Resources Quarterly Report	CPO	To note
Vision Zero Update	D CP	To note
Pedestrian Behaviour and Risk Management Research	D City Planning	To note
Energy Strategy	D City Planning	To note
Air Quality Update	D CP / MD LU	To note
Strategic Risk Update	D HSE	To note
Transformation Update	D Transformation	Standing Item
Corporate Environment Framework	D CP	To note

12 February 2020		
Quarterly Health, Safety and Environment Performance Reports (to include resilience, assurance and compliance issues)	D HSE	To note
Human Resources Quarterly Report	CPO	To note
Bus Driver Facility Improvements	MD ST	To note (6 monthly standing item)
Strategic Risk Update	D HSE	To note
Transformation Update	D Transformation	Standing Item

Regular items

- Quarterly HSE Performance Report – standing item
- HR Quarterly Report – standing item
- Bus Driver Facility Improvements – six monthly update
- Transformation update – standing item
- Review of CIRAS Report and Themes - annual
- Strategic Risk