



Bus Safety Standard

Executive Summary



**TRANSPORT
FOR LONDON**

in conjunction with



Metroline

LK61BJ0



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Foreword

Safety is at the heart of Transport for London's bus operations. The Mayor of London has made clear that loss of life and serious injuries on London's roads are neither acceptable nor inevitable and Transport for London's has now adopted Vision Zero for London, with a target of zero deaths or serious injuries by 2041. For buses we have an even more ambitious target of no one killed in, or by, a London bus by 2030. This is no doubt a challenging target, but we are determined to meet it and a key part of our strategy is to develop new safety features on buses.

In February 2016 we launched our bus safety programme, including a commitment to develop a 'Bus Safety Standard', to ensure that the safest buses are driven on London's roads.

Since then we have commissioned TRL (the Transport Research Laboratory) to research and develop that standard. This has been an evidence-based and collaborative project, consulting with the bus manufacturers and operators on technical feasibility, timelines and implementation so that we have the confidence that the safety measures will make a real contribution to Vision Zero.

Today we are launching this world-leading Bus Safety Standard. The Bus Safety Standard will provide a substantial proportion of the casualty savings required to meet our targets, and this document summarises the safety measures featured. Not all the technologies are available immediately and some will require development time, so our bus safety roadmap sets out our future plans for the buses, to give the manufacturers time to invest in these new safety features. The standard will continue to evolve to take account of technology innovations in the future.

It is crucial that we all continue to work together to ensure we reduce to zero the number of people killed or seriously injured on our bus network. While we are launching the Bus Safety Standard in London the benefits are potentially global, and we encourage everyone to join the call for raising the safety standard of buses.



Claire Mann, 16/10/2018
Director of Bus Operations,
Transport for London



1. The Bus Safety Standard (BSS)

The Bus Safety Standard (BSS) is focussed on vehicle design and safety system performance and their contribution to the Mayor of London's Transport Strategy. This sets a target to achieve zero road collision deaths involving buses in London by 2030.

To develop the standard a large body of research and technical input was needed, so Transport for London (TfL) commissioned TRL (the Transport Research Laboratory) to deliver the research and consult with the bus industry. The delivery team has included a mix of engineers and human factors experts, to provide the balance of research required.



All TfL buses conform to regulatory requirements. TfL already uses a more demanding specification when contracting services and this requires higher standards in areas including environmental and noise emissions, accessibility, construction, operational requirements, and more. Many safety aspects are covered in the specification such as fire suppression systems, door and fittings safety, handrails, day time running lights, and others. However, the new BSS goes further with a range of additional requirements, developed by TRL and their partners and peer-reviewed by independent safety experts.

Accompanying the specification there are guidance notes to help inform the bus operators and manufacturers of what the specification is aiming to achieve and some practical tips on how to meet the requirements.

For each safety measure considered, a thorough review was completed covering the current regulations and standards, the specification of the current bus fleet and available solutions.

Full-scale trials and testing were also carried out with the following objectives. Firstly, the tests were used to evaluate the solutions in a realistic environment to ensure that a safety improvement was feasible. Secondly, the testing was used to inform the development of objective test and assessment protocols. These protocols will allow repeatable testing according to precise instructions so that the results are comparable. The assessment protocol provides instructions for how to interpret the test data for a bus or system, which can be a simple pass/fail check, or something more complex intended to encourage best practice levels of performance. These assessment protocols will allow TfL to judge how well each bus performs against the BSS, and will allow a fair comparison in terms of safety if they have a choice between models for a given route.



It is important to ensure the money is spent wisely on the package of measures that will give the most cost-effective result. If zero fatalities can be achieved at a low cost it remains better than achieving it at a higher cost. TRL has developed a cost-benefit model describing the value of implementing the safety measures, both in terms of casualties saved and the technology and operational costs of achieving that. Input from the bus industry has formed the backbone of all the research and the cost benefit modelling. This modelling has helped inform the decisions of TfL's bus safety development team in terms of implementing the safety measures on new buses.



This Bus Safety Standard booklet sets out the safety measures that are being incorporated. It describes each measure in turn, and it also describes the Bus Safety Roadmap that sets out the future requirements for the bus industry. Finally, it describes the Bus Safety Innovation Challenge which is the framework by which new innovative technologies will be assessed as they become available on buses.



2. Driver Assist (helping the driver to avoid or mitigate the severity of incidents)

2.1 Advanced Emergency Braking (AEB)

Advanced Emergency Braking (AEB) systems use forward looking sensors such as Lidar, Radar, Camera, or fusions of data from more than one sensor, to identify a risk of an imminent collision. It will typically first warn the driver of the risk and, if the driver does not act, then it will apply braking automatically to avoid the collision or to reduce the collision speed and therefore the potential for injury. It will warn and intervene in an emergency in the last few seconds before an impact, and provides braking much later than during normal driving. Systems will be available that respond in front-to-rear collisions with other vehicles and frontal collisions with pedestrians crossing the road, or cyclists travelling more slowly ahead of the bus.

AEB standards have previously been developed for HGVs and cars, but buses pose a unique additional challenge because of the multiple passengers that are seated and unbelted, or who might be standing. AEB has been proven effective in other vehicle types, in both front-to-rear vehicle collisions and pedestrian collisions. Analysis strongly suggests it will provide considerable benefit when fitted to buses too. However, on very rare occasions, an AEB system can activate when it didn't need to (a false positive) because it incorrectly identified a collision threat.

For all vehicle types this creates a risk of unnecessary collisions with following vehicles, but for a bus, each false activation also carries a risk that it could cause passenger injury.

“Buses pose a unique additional challenge because of the multiple passengers that are seated and unbelted, or who might be standing.”



Advanced Emergency Braking (AEB) applies braking (if the driver is unresponsive) to avoid the pedestrian.

Considerable attention has, therefore, been paid to modelling the balance between collision avoidance and the risk of injury to passengers on board. This includes consideration of the vulnerable road user (VRU) casualty savings, the changes in casualties amongst passengers on board if a collision is prevented, and the risk of additional casualties resulting from false activations. Testing has been used to develop a test track-based assessment procedure, adapted from Euro NCAP's AEB tests for cars. In addition, the test procedure includes some innovative tests designed to discourage false positives that might arise from less robustly developed systems; although it will never be possible to test against all possible situations because driving circumstances are so varied and complex. It also requires manufacturers to show TfL additional evidence to demonstrate the false activation rate will be sufficiently low to ensure substantial net casualty benefits and requires the AEB system to make data available to on-board recording systems to allow close monitoring of performance in service.

In the future, AEB systems are expected to emerge with a greater functionality, not yet feasible on buses. This might include different collision targets such as bridge strikes and might include different driving scenarios such as junctions and turning across the path of other vehicles. A system to prevent collisions in the event of pedal application error is another promising area, where incremental technical developments of the system could help TfL achieve their targets.

2.2 Intelligent Speed Assistance (ISA)

TfL has previously committed to rolling out buses fitted with Intelligent Speed Assistance (ISA). This is an aid to the driver for keeping to the speed limit. The system is based on a digital speed map of London containing road speed limit information. The system interprets the speed limits and prevents the driver from accelerating the bus above the limit. The test and assessment protocols have now been developed to verify the performance of the ISA systems against TfL's existing specification. The numbers of ISA equipped buses in TfL's fleet continue to increase in line with their roll out plan.

“ISA interprets the speed limits and prevents the driver from accelerating the bus above the limit.”



Intelligent Speed Assistance (ISA) supports the driver with keeping to the speed limit.

2.3 Improved Direct and Indirect Vision

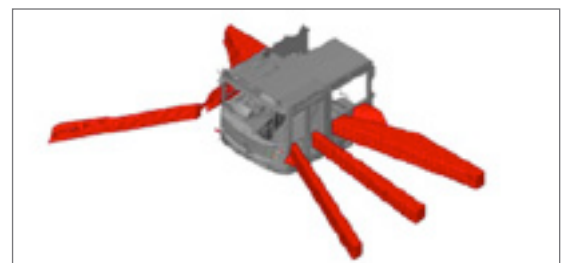
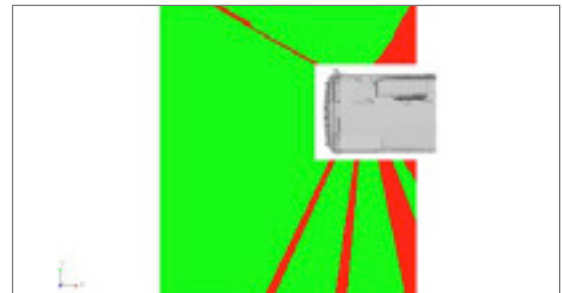
A driver’s ability to respond to imminent collisions is dependent on how well they can see out of and around the bus. Direct vision is concerned with what is in the driver’s sightline, whereas indirect vision concerns blind spot visibility by use of mirrors or camera systems. Compared with Heavy Goods Vehicles (HGVs), buses generally have very good direct vision because they are relatively low to the ground with large windows. However, the regulatory requirements for indirect vision are much less demanding for buses than for HGVs and some blind spots remain. The BSS will incorporate requirements to minimise direct vision obstructions from pillars and improve indirect vision via the use of mirrors, or blind spot information systems and Camera Monitor Systems (CMS) in the future.

“Direct vision is concerned with what is in the driver’s sightline, whereas indirect vision concerns blind spot visibility by use of mirrors or camera systems.”

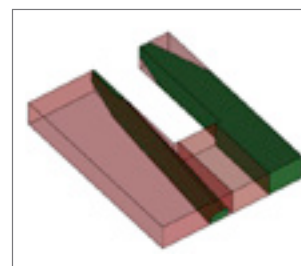
2.3.1 Bus Vision Standard

The assessment approach is based on the similar standard TfL are implementing for HGVs. However, it has been adapted to suit the different technical challenges presented by buses. It is based on defining a volume of space around the bus, where other road users may be positioned and at risk when the bus is manoeuvring. It measures how much of the volume can be seen by the driver. It considers the view from both direct and indirect vision and includes consideration of potential internal obstructions such as those that can be caused either by pillars or reflections on some assault screens. It uses sophisticated computer techniques to ensure a complex measurement process can be undertaken with minimal effort and be easily incorporated in the design process by bus manufacturers.

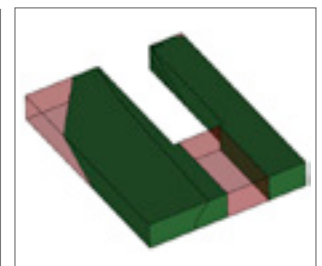
The assessment zones are divided into different areas and weighted in terms of the number of casualties associated with them. Separate research by the TfL freight team has shown direct vision to be preferable to mirrors so minimum standards have been set separately for the score that must be achieved by direct vision alone, and the overall score that must be achieved by both direct and indirect vision together.



Vision assessment involves measuring how much is in the driver’s sightline (green) and how much can’t be seen (red).



Driver view (green) rearward of cab using standard Class II mirror only.



Driver rearward view increased by combining Class II mirror with blind spot mirror.

The test and assessment protocol permits the substitution of mirrors by camera monitor systems (CMS), provided they comply with the relevant regulations. This approach removes the risk of a mirror hitting a pedestrian, but is very new and the effect on driver workload and behaviour is not yet well documented. There may be opportunities for further benefits in minimising blind spots and helping drivers to see hazards around them, but there may be risks if drivers do not find them as natural to use. These will be considered a requirement in future, subject to evidence confirming the balance of risks and opportunities, and research to better define their specification.



A Camera Monitor System (CMS) can replace the wing mirror and help to reduce blind spots.

2.3.2 Information, Warning & Intervention Systems

Good direct and indirect vision alone will not eliminate all casualties in manoeuvring collisions; the driver must still be looking in the right direction at the right time. Systems that give the driver additional information about the hazards around the bus, or warn of imminent collision, still have an important role to play. How these information and warnings are communicated to the driver is critical to their success and a draft standard accounting for different functionalities, the avoidance of false alarms, and the appropriateness of the human machine interface (HMI) has been developed.



Additional sensors on buses can help to detect cyclists in blind spots.



Software algorithms can distinguish cyclists from the background.

“The driver presses the accelerator when they think they are pressing the brake pedal.”

2.4 Pedal Application Error

Pedal Application Error refers to situations where the driver presses the accelerator when they think they are pressing the brake pedal, which leads to an unintended acceleration. It happens extremely rarely but carries a risk of very severe outcomes. It is very difficult to understand exactly what happens in these events, and drivers are unaware of their mistake. TfL is now requiring CCTV cameras to be fitted in the footwell to provide evidence in case of future incidents. In the meantime, there are a variety of measures to help a driver place their foot correctly or recover from an unintended acceleration incident.

2.4.1 Foot Placement

One solution that might help driver’s to correctly place their foot on the brakes is brake ‘toggling’. This refers to an additional press of the brake pedal at a bus stop or bus stand (not in flowing traffic) to update the driver’s recent memory of the brake pedal position. The idea is that if the driver’s brain has more frequent memory updates of where the brake pedal is, then they are less likely to place their foot incorrectly.

Another theory about pedal application error is that the driver’s feet might become misaligned from the pedals if the driver must move to see into a blind spot. The Bus Vision Standard is intended to reduce the blind spots, and as a consequence might also help to reduce the risk of pedal foot placement error.



Pedal application error is a rare but high risk event when the accelerator is pressed instead of the brake pedal.

The design of bus pedals is controlled by regulation, and many manufacturers build following ISO standards. However, there is still some variation between models, and if a driver drives different buses, they may become confused by different pedal layout or feel. In an ideal world, all the bus pedal configurations would be identical.

2.4.2 Recovery

It may be possible to help the driver recover from an error if a pedal application error incident does occur. CCTV evidence shows that a small proportion of incidents last for a surprisingly long time, with some even approaching a minute in duration. The driver is so convinced that they have their foot on the brake, they just keep pressing it. In these cases, a driver feedback system may help the driver to realise their mistake. Feedback could include visual indication or the addition of engine noise simulation in quiet (electric/hybrid) vehicles.

2.4.3 Intervention

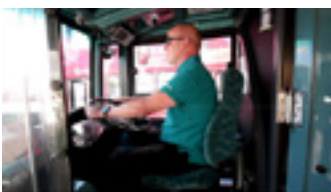
Future Advanced Emergency Braking (AEB) systems might be able to intervene in the case of pedal application error. AEB is intended to help the driver when they are distracted or cannot react fast enough, so an AEB is generally overridden if there is a strong input (braking or acceleration or steering) from the driver. However, it would be feasible to adapt the logic and allow advanced emergency braking if the accelerator pedal was depressed fully, and the AEB system detected an imminent collision, particularly if the system could distinguish between normal throttle activation and one where the driver really meant to hit the brake.

2.5 Runaway Bus Prevention

In rare circumstances runaway buses can occur. These are exceptional occasions where the driver leaves their seat without properly applying the park brake and the bus subsequently rolls away. These incidents are very rare but carry a risk of very severe outcomes.

The research for this safety measure included task analysis and interviews with drivers about the extreme circumstances that might lead to a runaway incident. This analysis was used to generate a checklist of conditions whereby the bus should not roll away. The BSS will require a system of interlocks to prevent the bus rolling away if the driver leaves their seat without properly applying the park brake. The checklist is used to assess the performance of the runaway bus prevention interlocks.

“A system of interlocks to prevent the bus rolling away if the driver leaves their seat without properly applying the park brake.”



System on, driver in control and in seat so bus can roll.



System on, driver out of seat, interlock engages and bus held on brakes.

3. Partner Assist (helping the other road users involved, the collision partners, to avoid the collision)

3.1 Acoustic Conspicuity

An Acoustic Vehicle Alerting System (AVAS) is a system to make quiet running (e.g. electric) buses as identifiable to pedestrians, and other road users outside the vehicle, as a standard diesel bus. This is intended to help Vulnerable Road Users (VRUs) detect the presence of a bus and the collision risk it represents if they were to cross in front of it. Regulation will require that electric and hybrid buses are fitted with AVAS, on new models from September 2019, and on all new builds from 2022. TfL is mirroring the regulatory requirements but has chosen to implement them sooner, subject to legal review. TfL is also investigating the development of a “city bus” sound. The aim of this is to harmonise the AVAS sounds across the bus fleet, regardless of which company has manufactured the bus, thereby minimising the number of new sounds introduced into an already very busy and noisy environment, and avoid the risk of confusing VRUs. An evaluation procedure has been developed to assess solutions and aid the design/selection of the city bus sound.



Participants were blindfolded so they focused only on what they could hear.



Acoustic conspicuity trials showed a greater effectiveness of the sound coming from the front of the bus.



Participants pressed the button when they heard the bus.

“An Acoustic Vehicle Alerting System (AVAS) is a system to make quiet running (e.g. electric) buses as identifiable to pedestrians, and other road users outside the vehicle, as a standard diesel bus.”

3.2 Visual Conspicuity

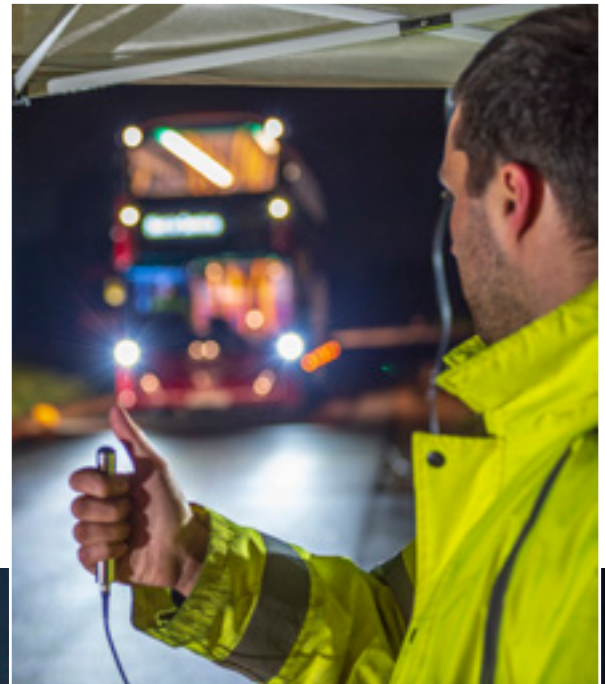
Visual conspicuity is about making the bus more noticeable to other road users, particularly VRUs. This might help VRUs to detect the presence of a bus and the collision risk it represents if they were to cross in front of it. There are a variety of solutions available that might help, and TfL is requesting innovative solutions to be evaluated. Test and assessment procedures will have to be developed for specific solutions that are selected in the future.

“TfL is requesting innovative solutions to be evaluated.”

The assessment of the visual conspicuity solutions has required the development of a new evaluation procedure. This consists of a laboratory-based test reviewing photos of buses in a variety of conditions. This assesses the participants' ability to search and recognise the bus in a London visual scene. A second phase of testing is track-based and assesses how well participants judge their ability to successfully cross in front of an approaching bus (by releasing the button, but not stepping out). These procedures were designed to assess the 'looked but failed to see' and 'time to collision' (or saw but misjudged the risk) errors respectively.

Within the regulatory requirements it is possible to add extra marker lights to buses. Additional reflective tape was also investigated, as well as the combination with both lights and tape. The idea is that by creating a rectangular frame of the shape of the bus front then VRUs might better identify and predict the speed of the bus as the rectangle enlarges whilst moving towards them. These conditions were tested against a baseline bus, but were not proved to be more effective for fully able people. However, TfL intends to look at whether these solutions could be effective for impaired persons, such as visually impaired or intoxicated people.

Participants let go of the button when they felt it was no longer safe to cross.



Trials assessed the effect of adding a reflective tape outline, additional top marker lights, and both together.



4. Partner Protection (reducing severity of injuries for road users outside the bus in a collision)

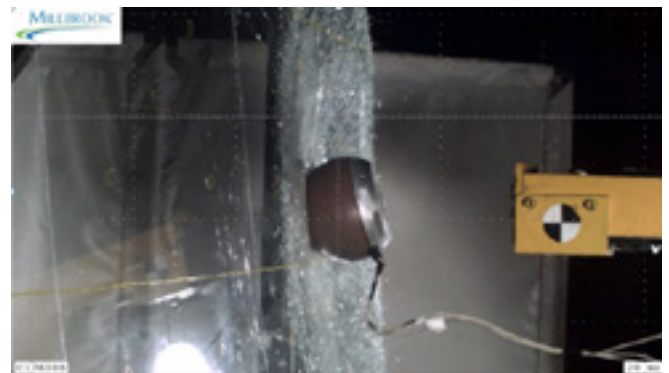
4.1 Vulnerable Road User (VRU) Frontal Crashworthiness

This safety measure concerns the protection of VRUs if a collision with the front of a bus is unavoidable. The aim is to provide better protection and lessen the injury severity. This can include changes to the geometric front end design of the bus, impact energy performance assessment, and runover prevention systems. Also included is the impact performance of wing mirrors and their potential replacement with camera monitor systems (CMS).

“Protection of Vulnerable Road Users (VRUs) if a collision with the front of a bus is unavoidable.”

4.1.1 Impact Protection – Energy absorption

When a collision between the bus and a pedestrian occurs, there is often an impact between the bus and the pedestrian’s head. It is possible to reduce the accelerations experienced by the head through the use of energy absorbing materials, avoiding hard points under the front panels in the design stage, or even by altering the front profile of the bus. The BSS sets minimum head impact performance requirements to ensure that the accelerations experienced by the head do not exceed specified injury criteria.



Windscreens with a flatter curvature offer a better head impact protection.

4.1.2 Impact Protection – Windscreen wiper protection

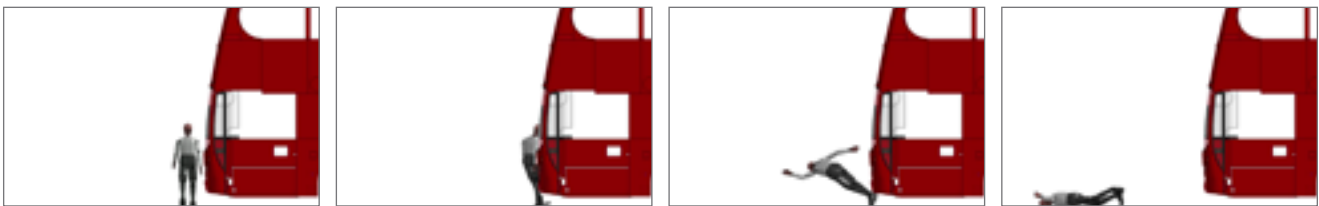
The windscreen wipers can have an effect on pedestrian injuries, should a bus-to-pedestrian collision occur. The wiper mount points are hard and can potentially cause injury. Two potential solutions exist, depending on the bus styling and wiper sweep. First is moving the mount points up to the top of the screen and out of likely impact range. If this is unfeasible, a second option is for manufacturers to provide evidence that a protective or energy absorbing covering for bottom-mounted wipers has been fitted and is effective.



Windscreen wiper protection must be provided, unless they are located at the top of the screen out of harm’s way.

4.1.3 Bus Front End Design

Changes to the front end design, or shape of the bus front, can help to deflect the pedestrian out of the path or to scoop them up and along, instead of pushing them down onto the ground. Shape changes for the bus front have been investigated in innovative research using computer simulations. As a result, the BSS will require rounded corners at the front of the bus, combined with a slightly sloped front. These combine to create design envelope requirements to deflect VRUs laterally and upwards away from the bus to reduce injury and run-over risk. Some of TfL's bus fleet already has these features, and this set of minimum requirements will be adopted in the BSS for new build buses. Future research to generate more optimised requirements will consider different speeds, different material properties, and cyclists.



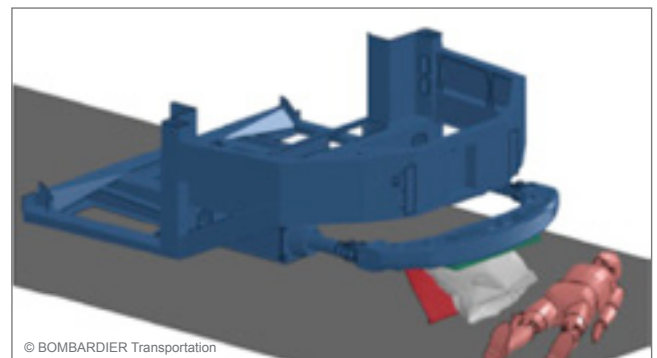
Previous generation bus impacting an average male pedestrian who is pushed downwards to the ground.



Future buses will have a more sloped windscreen and more rounded corners to help deflect pedestrians more upwards and laterally to reduce run-over risk.

4.1.4 Run-Over Protection

Pedestrians are at the greatest risk of fatality if they are run over after an impact. TfL is keen to see innovative designs from bus manufacturers that will help to prevent run-overs. This might include a mechanical or airbag device located under the bus that is only dropped down on contact with a pedestrian. Bombardier has developed the BodyGuard™ system for trams. Run-over protection solutions need development on buses so cannot yet be incorporated into the BSS, but TfL calls for innovation in this area.



A run-over protection system has been developed for trams, but innovation is needed for buses.

4.1.5 Mirror Strikes

Camera Monitor Systems (CMS) are now entering the market for buses, with these systems replacing the wing mirrors with cameras that provide the same view. Images are shown on a monitor that is mounted inside the bus in a similar place to the wing mirror, e.g. on the A-pillar. These systems have the advantage of removing the wing mirrors, which will remove the risk of mirror strike injuries to pedestrians and other road users. The BSS will require that CMS are fitted, but some further research is needed to define exactly how these should be implemented on buses for a suitable cab layout and in a way that does not over-burden the driver with information.

5. Occupant Protection (reducing severity of injuries for people on board the bus)

5.1 Occupant-Friendly Interiors

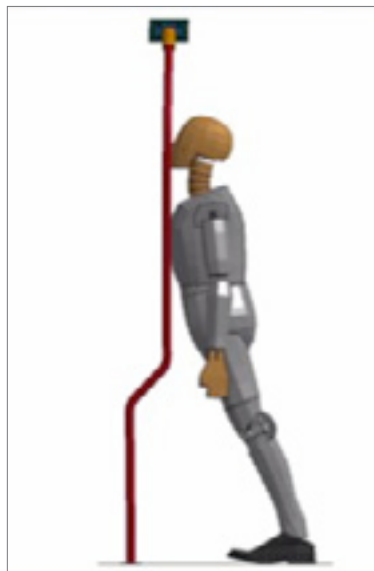
Considering bus passenger injuries, the majority of the more severe casualties and fatalities occur in collisions, but a large number of slight injuries occur in non-collision incidents such as harsh braking. TfL’s BSS is supporting safety improvements for bus passengers as a priority. This involves an assessment of the protection provided to passengers on-board the bus. A visual inspection of the interior during the design process aims to help identify and design-out potentially injurious features and encourage better positioning and selection of features.

The occupant-friendly interiors measure has been particularly challenging. Current regulations heavily constrain designs for reasons of accessibility, so making safety improvements without conflicting with regulations and other priorities such as passenger flow and comfort is difficult. Nevertheless, beneficial changes have been identified. The process has been to examine CCTV footage to help understand how passengers are injured in harsh manoeuvre (e.g. emergency braking) and collision events. Following this, existing bus designs were reviewed to identify potentially injurious features and how they could be redesigned to reduce the risk of injury, e.g. move the handrail to reduce risk of a head strike. An assessment scheme for occupant-friendly interiors has been developed to allow bus manufacturers to incorporate safety considerations alongside the existing constraints from regulation, accessibility, flow etc. It is hoped that this will give the manufacturers a guide for producing the best compromise, without being too design prescriptive.

Some passenger injuries occur from impacts with the grab poles on buses. Computer simulation was used to model a grab pole and a passenger impact onto the pole. The regulation is quite restrictive because the pole has to remain small enough to grip, so it is not possible to add a lot of protective foam. The particular solution tested did not show a consistent improvement, so TfL calls for innovation in this area.



Baseline pole



Pole with compliant mount at the top under emergency braking.



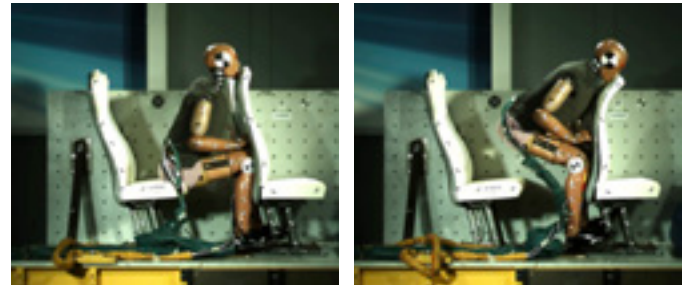
Pole with compliant mount at the top in a severe crash.

Low back



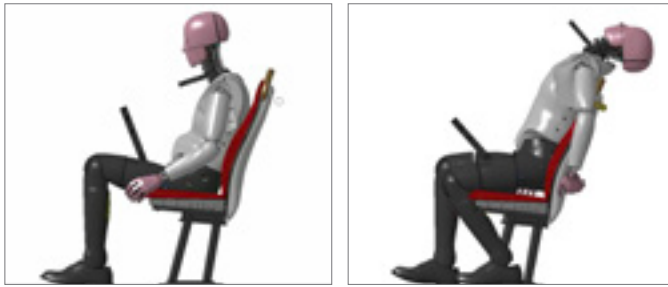
Passenger is poorly restrained.

Medium back



Passenger is better restrained by a medium back seat.

Low back



Low back allows large neck extension when rear facing.

High back



High back reduces neck extension when rear facing.

Passengers can also be injured in frontal impacts or when the bus brakes because this causes them to move forward into the seat in front. The development of the BSS included seat testing, both in computer simulation and sled testing (which replicates the collision forces in a repeatable way, but for testing just the seat in isolation and not the whole vehicle). This testing compared traditional low-back seats against medium (taller) back seats and high back (for example coach style) seats. In rear-facing seats the BSS will encourage high-back seats. The additional weight of these different seats makes them difficult to implement throughout the entire bus. TfL calls for innovation to develop a seat design that can provide greater protection, particularly against whiplash injury in rear-facing seats, but also be lightweight and robust for implementation on a public bus.

“Passengers can also be injured in frontal impacts or when the bus brakes because this causes them to move forward into the seat in front.”

5.2 Slip Protection

Slips on buses are also a cause of injury for bus passengers. There are well established methods of measuring the slip resistance of flooring, and these have been modified to suit buses. The test method involves using a pendulum device with a swinging shoe plate; the greater the resistance the less the shoe plate moves after it hits the floor. The BSS will require a minimum skid resistance of the anti-slip flooring fitted in the buses.



The Portable Skid Resistance Tester (PSRT).



Slip resistance in use was investigated; measurements will use samples for new buses.

“A minimum skid resistance of the anti-slip flooring fitted in the buses.”

6. Implementation of the Bus Safety Standard

The BSS will be implemented on all new buses entering the London fleet. The timings of the implementation will be as predefined in the bus safety roadmap.

The tests and assessments are tailored to suit the nature of each safety measure. They are either a simple pass/fail or a more complex performance assessment. Injury and collision data have been used to define the scenarios and/or injury mechanisms to be addressed. As such it is an objective, performance-based assessment. The assessments have been written in a way that is open for the bus industry to deliver new innovative safety features that achieve the goal, without being restricted as to how it is attained. Guidance notes have been developed to help the bus manufacturers and operators with some practical advice.

“The BSS will be implemented on all new buses entering the London fleet.”



7. The Bus Safety Roadmap

A roadmap has been developed by TRL to provide a guide for future developments of the BSS. This is needed because not all the safety features and systems are available immediately on buses. Some features will take time to develop and implement on buses because they are new and innovative. The bus industry has been consulted through the research process so that the timescales are realistic but challenging. The bus manufacturers will have to work with their supply chains to meet this demand.

This roadmap is the key tool for bus manufacturers and operators in understanding TfL's requirements and will enable them to plan for the future. It will be an evolving document with regular updates so as to remain relevant. The Euro NCAP (European New Car Assessment Program) roadmap for passenger car safety has been used as the model approach.

Historically, TfL's bus procurement has been based on the specification of buses, and its requirements, which is essentially setting a minimum standard. The roadmap is now presenting a 'Preferred' date earlier than any 'Required' date. This 'preferred' date reflects when the vehicle or system might first enter the market in production by the market leader, to encourage the earlier adoption of safety systems. The 'required' date represents when multiple bus models would be expected to be available to the market and will typically follow a few years later.

"The bus industry has been consulted through the research process so that the timescales are realistic but challenging."



8. The Bus Safety Innovation Challenge

The BSS marks a fundamental change in the approach to safety for London's buses, but there are many other safety systems that could be implemented on buses, or innovations yet to come. The bus industry and its supply chain can offer a vast range of safety improvements. To encourage and guide the development of these improvements TfL aims to provide support through the Bus Safety Innovation Challenge.

Applicants will need to provide a dossier of evidence describing a safety system and its effectiveness for assessment. The purpose of this assessment is to provide consistent targets to innovators so that they know what TfL is trying to achieve, what their innovation will need to do, and what proof will be needed, for TfL to consider allowing or requiring it on London buses. TfL has evidence underpinning the range of ongoing bus safety projects, and the innovation challenge is intended to encourage innovators to focus on that evidence to really help TfL to reduce or eliminate fatalities and injuries on London's bus network.

A two-stage approach is used to assess the submission. The first stage covers a description of the innovation and how it works, alongside a description of the safety problem and casualty population that it is intended to avoid or mitigate. The second stage is more complex, with three sections. Evidence of how the innovation has been tested should be used to demonstrate its effectiveness and suitability for buses, and this should then be used to describe the expected benefit in terms of the number of casualties it is expected to avoid in real service. Finally, any real world evidence should be used to quantify the observed safety benefits that were actually achieved, operational implications such as driver or passenger reactions to the system, and costs.

“There are many other safety systems that could be implemented on buses, or innovations yet to come.”

“To encourage and guide the development of these improvements TfL aims to provide support through the Bus Safety Innovation Challenge.”

9. Conclusion

Ultimately, the goal of the Bus Safety Standard research was to develop an independent standard and framework for assessing the safety of TfL's buses. Bringing all the safety measures together and ensuring that they work in a complimentary manner was complex. The BSS programme has delivered innovative research into new areas of bus safety.

The BSS is intended to be a rolling programme, so this initial large programme of research is just the starting point for TfL. Testing and trials will continue to investigate the capability of new technologies and bus features via the Bus Safety Innovation Challenge. The specifications will be updated regularly to keep extending the preventative and protective benefits of these and future safety measures on buses. The roadmap will be updated to help inform the bus industry of these forthcoming requirements.

Strong steps towards safer buses for London are achievable through this world-leading Bus Safety Standard, which we hope will be taken up by other safety-conscious transport authorities, bus manufacturers and operators wherever they are based across the globe.

“The BSS programme has delivered innovative research into new areas of bus safety.”



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