Bus Safety Standard

Future Roadmap

BUSES
TRANSPORT FOR LONDON
in conjunction with
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Executive Summary

TRANSPORT FOR LONDON

Bus Safety Standard roadmap for new build buses

Group	Area	Measure	2018	2019	2020	2021	2022	2023	2024	2025	2026	onwards
Driver Assist	**Intelligent Speed Assistance (ISA)**	Standalone mandatory	Required									
Driver Assist	**Advanced Emergency Braking (AEB)**	Car, pedestrian & cyclist partners			Preferred				Required			
Driver Assist	**Runaway Bus Prevention**	Interlock system		Preferred		Required						
Driver Assist	**Pedal Application Error** – Foot placement	Brake toggling		Preferred		Required						
Driver Assist	**Pedal Application Error** – Foot placement	Pedal standardisation			Preferred	Required						
Driver Assist	**Pedal Application Error** – Recovery	Pedal indicator lights		Required								
Driver Assist	**Pedal Application Error** – Recovery	Pedal acoustic feedback		Preferred		Required						
Driver Assist	**Pedal Application Error** – Intervention	AEB logic			Preferred				Required			
Driver Assist	**Vision –** Direct & indirect vision standard	Direct vision		Preferred		Required						
Driver Assist	**Vision –** Direct & indirect vision standard	Enhanced indirect vision			Preferred				Required			
Driver Assist	**Vision –** Direct & indirect vision standard	Class II Camera Monitor Systems (CMS)			Preferred	Required						
Driver Assist	**Vision –** Direct & indirect vision standard	Blind spot Mirrors		Required								
Driver Assist	**Vision –** Direct & indirect vision standard	Blind spot CMS			Preferred	Required						
Driver Assist	**Vision –** Direct & indirect vision standard	Reversing CMS		Required								
Driver Assist	**Vision –** Direct & indirect vision standard	Front & nearside warning systems			Preferred				Required			
Driver Assist	**Vision** – Internal obscuration	Driver assault screens		Required								
Partner Assist	**Acoustic Conspicuity**	Acoustic vehicle alerting system		Required								
Partner Protection	**VRU Frontal Crashworthiness** – Bus front end design	Minimum geometry		Preferred		Required						
Partner Protection	**VRU Frontal Crashworthiness** – Bus front end design	Optimised geometry					Preferred		Required			
Partner Protection	**VRU Frontal Crashworthiness** – VRU impact protection	Energy absorption				Preferred			Required			
Partner Protection	**VRU Frontal Crashworthiness** – VRU impact protection	Wiper protection		Preferred		Required						
Partner Protection	**VRU Frontal Crashworthiness** – Mirror strike protection	Class II CMS			Preferred	Required						
Occupant Protection	**Occupant Friendly Interiors** – Visual inspection & design	Level 1 requirements		Preferred		Required						
Occupant Protection	**Occupant Friendly Interiors** – Visual inspection & design	Level 2 requirements			Preferred				Required			
Occupant Protection	**Occupant Friendly Interiors – Slip** protection	Surface friction requirements		Required								

Bus Safety Roadmap for new build buses

Preferred – refers to a best practice approach and the first to market.

Requirement – refers to a minimum or mandatory requirement. This would represent a wider adoption throughout the London bus market, potentially 3+ models.

Years – indicates the year in which the preferred/required safety measure will be on the road. For manufacturers and operators it is important to note that this is not the tender, which may come 6-9 months prior to the buses becoming operational.

The coloured lines refer to TfL's roadmap according to the following categories:

- **Driver Assist**
- **Partner Assist**
- **Partner Protection**
- **Occupant Protection**

What is the Bus Safety Roadmap?

A roadmap has been developed by TRL to provide a guide for future developments of the Bus Safety Standard (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 because they are new and innovative. The bus industry has been consulted throughout 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.

This research was completed in 2018. The detailed specification, assessment procedures and guidance notes have been incorporated into the Transport for London specification for buses, which is a continuously updated document to keep pace with the latest technological and research developments, as is the roadmap. This report is not the specification/roadmap for a bus and should not be used as such. Bus operators, manufacturers, and their supply chain should consult with TfL for the specification/roadmap.

1 Bus Safety Standard (BSS)

1.1 The Bus Safety Standard

"The Bus Safety Standard (BSS) aims to reduce casualties on buses during normal operation and during collisions, and amongst other road users involved in bus collisions"

In 2018 the Mayor of London, Sadiq Khan, set out a 'Vision Zero' approach to road casualties in his transport strategy[1]. It aims for no one to be killed in, or by, a London bus by 2030 and for deaths and serious injuries from road collisions to be eliminated from London's streets by 2041.

Transport for London (TfL) commissioned the Transport Research Laboratory (TRL) to deliver a programme of research to develop a Bus Safety Standard (BSS) as one part of its activities to reduce bus casualties. The goal of the BSS is to reduce casualties on London's buses in line with the Mayor of London's Vision Zero approach to road safety. The BSS is the standard for vehicle design and system performance with a focus on safety. The whole programme of work includes evaluation of solutions, test protocol development and peer reviewed amendments of the Bus Vehicle Specification, including guidance notes for each of the safety measures proposed by TfL. In parallel to the detailed cycle of work for each measure, the roadmap was under continuous development alongside a detailed cost benefit analysis and on-going industry engagement. The programme is illustrated in Figure 1.

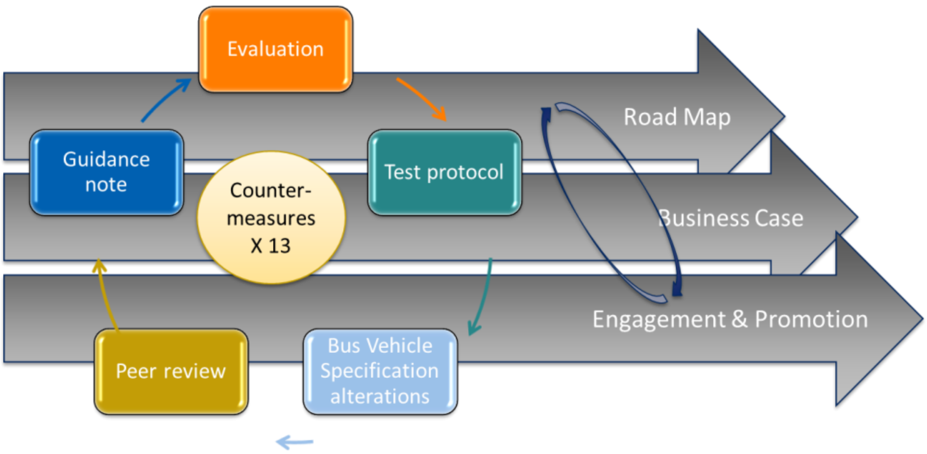


Figure 1: Summary of the Bus Safety Standard research programme

[1] Mayor for London (2018). Mayor's Transport Strategy. Greater London Authority, (GLA): London.

The exact methodology of the testing development depended upon each of the measures being developed. For Advanced Emergency Braking (AEB) it included track testing and on-road driving, whereas for the occupant interior safety measures it involved computer simulation and seat tests. There was also a strong component of human factors in the tests e.g. human factors assessments by our team of experts. In addition, there were objective tests with volunteers to measure the effect of technologies on a representative sample of road users, including bus drivers and other groups as appropriate to the technology considered.

The test procedures developed were intended to produce a pass/fail and/or performance rating that can be used to inform how well any technology or vehicle performs according to the Bus Safety Standard requirements. The scenarios and/or injury mechanisms addressed were based on injury and collision data meaning it is an independent performance-based assessment.

A longer-term goal of the Bus Safety Standard is to become a more incentive based scheme, rather than just a minimum requirement. The assessments should provide an independent indicator of the performance of the vehicle for each measure, and they will also be combined in an easily understood overall assessment.

This is an updated version of the BSS roadmap following the technical consultations throughout 2017 and 2018 with the industry, and it corresponds to the version presented at the TfL Bus Safety Summit on 16/10/2018.

1.2 Safety Measures

The measures selected for consideration in the BSS were wide ranging and are shown in Figure 2. Some will address the most frequent fatalities, which are the group of pedestrians and cyclists killed by buses, mostly whilst crossing the road in front of the bus. There are several measures that could address this problem, for example, Advanced Emergency Braking (AEB, which will apply the vehicle's brakes automatically if the driver is unresponsive to a collision threat with a pedestrian) or improved direct and indirection vision for the driver. These are both driver assistance safety measures, which are designed to help the driver avoid or mitigate the severity of incidents. Intelligent Speed Assistance (ISA) is another example of driver assistance, and TfL has already started rolling this out on their fleet. The last two driver assistance measures are pedal application error (where the driver mistakenly presses the accelerator instead of the brake) and runaway bus prevention; both of which are very rare but carry a high risk of severe outcomes.

Visual and acoustic bus conspicuity are both partner assistance measures that are designed to help other road users, particularly pedestrians and cyclists, to avoid collisions. Partner protection is about better protection if a collision should occur. For this the work has started with Vulnerable Road User (VRU) front crashworthiness measures, including energy absorption, bus front end design, runover protection and wiper protection.

Passenger protection is focussed on protecting the passengers travelling on board the bus, both in heavy braking and collision incidents. This encompasses occupant friendly interiors inspections, improved seat and pole design, and slip protection for flooring. This group of measures that help to protect bus occupants are important because around 70% of injuries occur without the bus having a collision.

Figure 2: Bus Safety Measures

Bus Safety Standard

Driver Assist

Helping the driver to avoid or mitigate the severity of incidents

- Advanced Emergency Braking (AEB)
- Intelligent Speed Assistance (ISA)
- Improved Direct and Indirect Vision
- Pedal Application Error
- Runaway Bus Prevention

Partner Assist

Helping other involved road users – the collision partners – to avoid the collision

- Acoustic Conspicuity
- Visual Conspicuity

Partner Protection

Reducing severity of injuries for road users outside the bus in a collision

- Vulnerable Road User (VRU) Frontal Crashworthiness

Occupant Protection

Reducing severity of injuries for people on board the bus

- Occupant Friendly Interiors
- Slip Protection

“This roadmap sets out timelines for the safety measures to be implemented as part of the BSS.”

2 The key elements of the bus safety standard

The development of the bus safety standard is intended to involve four major elements that it is hoped would be continued in the long term. The four elements are as follows:

- **The Bus Vehicle Specification:** This document represents the current status, defining in detail those safety requirements that must be met at the current time for TfL to contracting bus operations. Where applicable, the current list of preferred 'best practice' safety features will also be defined in this specification.

- **The assessment protocols:** These provide the manufacturers and operators clarity on what is required to demonstrate that any particular bus or bus feature complies with the requirements in the Bus Vehicle Specification. These will be technology and supplier neutral to avoid unintended barriers to competition or future innovation.
- **The future Bus Safety Roadmap:** Many safety features must be built in to the design of the vehicle. It can take significant time and money to develop a new safety system and this can be a substantial business risk in the absence of a clear market to sell that product into. The aim of the future Bus Safety roadmap is to clearly inform the bus and safety system supply chain what safety improvements they are expected to make sufficiently far ahead of their introduction to allow suitable development lead times. It aims to give industry some assurance that there will indeed be a market for their products once developed and should incentivise industry to be first to market, using free market competition to accelerate the introduction of new safety features.

- **The Innovation Challenge[2]:** The future Bus Safety roadmap is driven by TfL, its stakeholders and contracted researchers. The innovation challenge is intended to recognise that they not have a monopoly on good ideas. The award will create a standardised framework which will help innovators to develop new solutions to the safety needs of London and then demonstrate its effectiveness such that can decide whether to allow or require these safety features on future buses.

This document is the future Bus Safety Roadmap. The other elements are in separate documents.

"The Bus Safety Standard (BSS) comprises four key elements:

1) Amended and extended Bus Vehicle Specification

2) Performance based assessment protocols

3) Bus Safety Roadmap

4) Innovation Challenge"

[2] Note this is NOT the Innovation Award Fund. Instead the Innovation Challenge is a framework for an expert panel to assess the safety measure based on a dossier of evidence submitted by a third party.

3 Moving from Minimum Standards to rewarding Best Practice

3.1 Minimum Standards

Up until the development of the bus safety standard concept, TfL has applied mandatory minimum standards in its approach to bus safety. That is, a bus can only enter the TfL bus fleet if it meets or exceeds the minimum standard applicable (at the time) in the bus vehicle specification. This process is very similar to that used across Europe within vehicle type approval. It is the only mechanism that can ensure 100% compliance with requirements within any given market. As such, it is very important and will always remain in place to avoid the possibility of cost savings being prioritised at the expense of safety performance.

> *“Minimum standards increase safety slowly over time, but can breed a compliance culture.”*

The disadvantage of minimum mandatory standards is that they tend to be driven from the authorities down to industry. They must be applicable to all, and authorities are usually obliged to consider the impact on individual sections of industry such that they cannot ban all products except the best. Consequently, the standard tends to be set at a level that eliminates only a few of the very worst vehicles or systems from the market. Therefore, regular updating of the requirements is needed because of technical progress. This process is such that it generally requires the agreement of a broad constituency of stakeholders and sufficient lead time must be allowed so that disproportionate financial burdens are not placed on manufacturers. As a result, this process can therefore be quite slow. One final important aspect is that in areas where the end consumer does not see the immediate impact of a different design, it can remove the ability for consumers to discriminate between the levels of safety offered by different vehicles. Put simply, it is hard for manufacturers to invest in and sell a safety system when the competition can refer to an official regulation demonstrating their inferior system is also ‘safe’. Thus, it can in some areas breed a compliance culture: *‘Tell me what to do and I will do it for the lowest price possible’*.

3.2 Euro NCAP passenger car example

The passenger car market of the late 1980s and early 1990s could be characterised as described above. Governments were trying to improve safety through regulation, but progress was slow. Industry often resisted regulations and, with a few exceptions, made little effort to sell safety to the public. However, Euro NCAP started undertaking independent safety tests that had no regulatory power over the market and simply published simplified star rating results direct to consumers. This was initially resisted and at the time statements were made that it was impossible to achieve five stars etc. Then one manufacturer broke ranks and produced a five star car and advertised it heavily and successfully to consumers. Soon, many five star cars were on sale and today the bar required to achieve five stars is moved up every two years, most vehicles achieve four or five stars and the technology leaders are continuously competing to produce the safest vehicle.

> "Euro NCAP has successfully implemented testing that encourages car manufacturers to compete for higher ratings. The BSS will aim to reward best practice."

3.3 Best Practice in the bus market

The strategy outlined in the preceding section aims to follow this success and to introduce mechanisms to help bring these 'best practice' characteristics into the market for buses. As such, the technologies identified on the roadmap will be considered in terms of when they are first available, which might approximate to when they are available for consideration for incentives through a best practice mechanism. Consideration will also be given to how long it might take before the bulk of the market catches up with the leaders, such that a measure would be suitable for inclusion as a mandatory requirement, and how generations of systems might be expected to improve in performance over time.

However, implementing this approach in the bus market is not straightforward. The end consumer (passenger) is not involved in bus procurement and the decision as to which bus to buy is complex, with a strong influence of cost for the companies purchasing vehicles. Even beyond this, companies are formed of individuals and departments. The individuals responsible for buying a bus may not be from the same department as those tasked with safety and may be incentivised purely on cost minimisation. Thus, simply publishing best practice information may not be enough to replicate the effect of Euro NCAP in the bus market. Identifying suitable incentive is an ongoing challenge for TfL, without which the best practice elements may not be successful.

At this stage, only preliminary ideas are put forward to provoke discussion and TfL, bus manufacturers and bus operators will all be engaged to consider which approaches stand the best chance of success. Initial ideas include:

- Build best practice ratings into assessment process for tenders for bus routes, to increase likelihood that vehicles with best practice features are purchased.
- Express the best practice approaches as a safety score and pay some form of premium 'per point scored' to operators.

4 Casualty prevention priorities

Transport for London’s aim in implementing the bus safety standard is to assist in achieving ‘Vision Zero’ on the principle that no loss of life is acceptable or inevitable. Thus, the largest focus is on incidents resulting in death or serious injury. However, they recognise the disruption and cost that minor collisions can have for bus operators and the travelling public alike. Thus, safety features that can reduce the high frequencies of incidents of ‘damage only’ and/or ‘minor injury’ are also included within the scope. The high-level matrix below (Table 1) categorises and prioritises the casualties based on past data for London derived from the GB National accident database.

These priorities have informed the identification of the technologies considered within this roadmap and can, in future, be used as part of the Innovation Challenge to recognise new innovations identified by industry as and when they are brought forward.

It is possible that a safety measure may apply to one or more sections of the priorities table. For example, Intelligent Speed Assistance (ISA) can be thought of as a cross-cutting safety measure, because reduction of speed to within the limits could help to benefit all sections of the table. In other cases, a safety measure may only benefit a section of the table. For example, making changes to the interior of the bus will only benefit the bus occupants, and not the other road users.

“Bus occupants and pedestrians represent the highest proportion of casualty prevention value, making them the highest priorities.”

Table 1: Prioritised casualty groups

Casualty Type	Collision type	Fatal	Serious	Slight	KSI	Total
Bus Passenger	Injured in non-collision incidents - standing passenger	4.2%	17.1%	23.3%	11.9%	15.2%
	Injured in non-collision incidents - seated passenger	0.5%	6.4%	13.0%	4.0%	6.6%
	Injured in non-collision incidents - boarding/alighting/other	1.6%	7.6%	5.3%	5.2%	5.2%
	Injured in collision with a car	0.5%	4.6%	10.1%	2.9%	5.0%
	Injured in collision with another vehicle	0.0%	3.1%	5.0%	1.8%	2.8%
	Total	6.9%	38.7%	56.7%	25.9%	34.8%
Pedestrian	Injured in a collision while crossing the road with a bus travelling straight ahead	30.7%	20.0%	7.0%	24.3%	19.3%
	Injured in a collision, not while crossing the road, with a bus travelling straight ahead	10.6%	7.9%	4.6%	9.0%	7.7%
	Injured in a collision with a bus turning left or right	12.2%	3.1%	1.2%	6.8%	5.2%
	Injured in other collision with a bus	2.1%	1.4%	0.7%	1.7%	1.4%
	Total	55.6%	32.5%	13.6%	41.8%	33.6%
Car Occupant	Injured when front of bus hits front of car	6.3%	1.9%	0.9%	3.7%	2.9%
	Injured when front of bus hits rear of car	1.6%	0.8%	2.8%	1.1%	1.6%
	Injured when front of bus hits side of car	1.1%	1.1%	1.8%	1.1%	1.3%
	Injured in side impact collision with a bus	2.6%	1.9%	3.9%	2.2%	2.7%
	Injured in other collision with a bus	2.1%	1.0%	1.4%	1.5%	1.4%
	Total	13.8%	6.6%	10.8%	9.5%	9.9%
Cyclist	Injured in a collision with the front of a bus travelling straight ahead	2.1%	1.2%	0.9%	1.5%	1.4%
	Injured in a collision with another part of a bus travelling straight ahead	0.0%	2.6%	1.5%	1.6%	1.6%
	Injured in a collision with the nearside of a bus which is turning	1.6%	0.8%	0.4%	1.1%	0.9%
	Injured in other collision with a bus	0.5%	3.1%	2.1%	2.1%	2.1%
	Total	4.2%	7.8%	5.0%	6.4%	6.0%
Powered Two Wheeler (PTW)	Injured in a collision with a bus travelling straight ahead	2.6%	1.3%	0.7%	1.9%	1.5%
	Injured in a collision with a bus turning left or right	0.5%	1.0%	0.7%	0.8%	0.8%
	Injured in other collision with a bus	0.5%	1.0%	0.9%	0.8%	0.8%
	Total	3.7%	3.4%	2.3%	3.5%	3.2%
Bus Driver	Injured in collision with a car	0.0%	1.5%	2.5%	0.9%	1.4%
	Injured in non-collision incidents	0.0%	0.5%	0.5%	0.3%	0.4%
	Injured in collision with another vehicle	0.5%	1.2%	1.5%	1.0%	1.1%
	Total	0.5%	3.2%	4.5%	2.1%	2.8%
Other	Total	15.3%	7.9%	7.1%	10.9%	9.8%
Casualties Total		100.0%	100.0%	100.0%	100.0%	100.0%

5 Driver Assistance

Driver assistance measures are concerned with helping the driver to avoid or mitigate the severity of incidents.

5.1 Advanced Emergency Braking (AEB)

5.1.1 System definition

Advanced Emergency Braking (AEB) is a system that uses forward looking sensors in order to identify a risk of an imminent collision. The system will typically first warn the driver of the risk and, if the driver does not act, apply braking automatically in order to avoid the collision or to reduce the collision speed and therefore the potential for injury. Even ensuring that the vehicle is braking hard at the point of collision can have benefits for reducing the chance that a pedestrian is subsequently run over, even if the collision speed is not significantly reduced.

AEB is designed to address car, pedestrian and cyclist collisions. The specification and assessment protocol have now been defined for these three collision partner types.

5.1.2 Availability of the system

AEB Pedestrian first became available on passenger cars in 2010. In 2017, three-quarters of new passenger car models tested by Euro NCAP[3] had some form of AEB Pedestrian available and more than 60% had it fitted as standard. However, it is only just emerging on commercial vehicles. There are now several coach manufacturers with AEB available in 2018. Table 2 summarises the roadmap.

[3] Based on a review in July 2017 of the test reports for vehicles tested so far that year, see www.euroncap.com for the latest test results.

Table 2: Roadmap for AEB

	AEB
Prototype (test method development)	2017
Preferred (best practice / first to market)	2020
Required (production 3+ models)	2024

This roadmap assumes clear and effective market signals to industry and represents the earliest possible opportunities for implementation. This is based on industry liaison throughout the research programme, and agreement of the timelines with manufacturers in workshop in July 2018.

5.1.3 *Scope of vehicles to be equipped*

AEB could be applied to any new vehicle type likely to be used in London (single deck, double deck, diesel, hybrid or electric).

5.2 Intelligent Speed Assistance (ISA)

5.2.1 *System definition*

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.

5.2.2 *Availability of the system*

ISA is relatively mature at the technical level and GPS based systems are readily available, as shown in Table 3.

Table 3: Roadmap for ISA

	Stand-alone mandatory ISA
Prototype (test method development)	2017
Preferred (best practice / first to market)	2018
Required (production 3+ models)	2018

5.2.3 *Scope of vehicles to be equipped*

Application is likely to be to new vehicles only. Where retrofit has been identified as technically feasible then it has been rolled out during 2018.

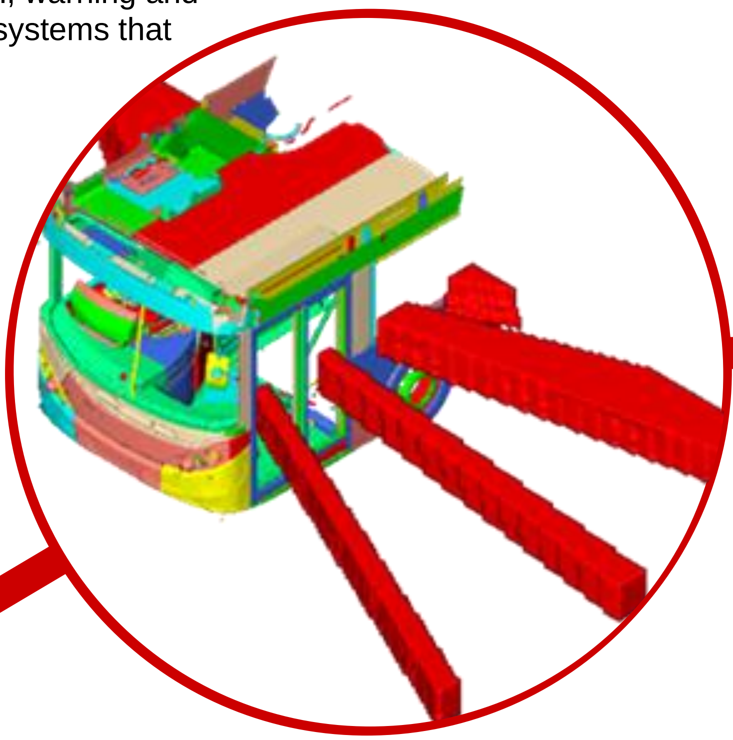
5.3 Improved Vision

5.3.1 System definition

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, blind spot information systems or camera monitor 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, 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 maintain current levels of direct vision performance and improve indirect vision via the use of mirrors, or blind spot information systems and Camera Monitor Systems (CMS) in the future.

Although grouped together under the heading of 'improved vision' there are a number of separate solutions that fall within the combined direct and indirect vision standard for buses:

- Direct vision: Increasing the direct field of view to the front and sides of the vehicle cab, for example by re-positioning hard features, minimising A-pillar widths, enlarging screens/windows, etc.
- Indirect vision: Increasing the indirect field of view around the bus, for example by installing new mirrors, CMS with wider fields of view, etc.
- Alternative/additional blind spot mirrors..
- Camera monitor systems (CMS): These involve replacing one or more external mirrors with a camera and using one or more monitors placed inside the vehicle to reproduce the same or better view. These can cover Class II zones, blind spots and reversing views.
- Front/nearside information signal, warning and intervention systems: these are systems that provide the driver with additional information about VRUs in close proximity to the bus, warn of an imminent collision with a VRU or inhibit the forward motion of a bus prior to moving-off from rest if a VRU is located in the vehicle path.
- Internal obscuration: the driver assault screen should be designed so that it does not interfere with the direct or indirect vision of the driver, including it's angle of curvature.



5.3.2 *Availability of the system*

For most of the vision issues there are already best practice examples in London's fleet, for example reversing cameras are already widely fitted.

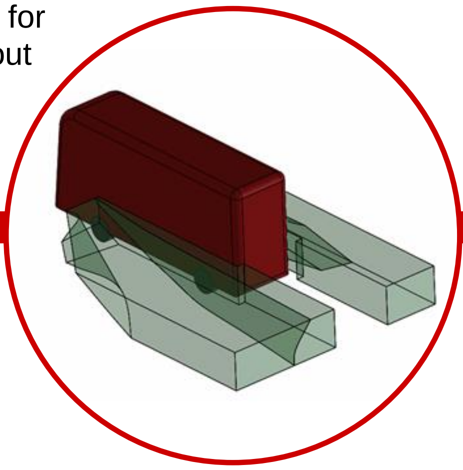
Replacing mirrors with camera monitor systems was made legal in 2016 by amendments to UNECE Regulation number 46, with Regulation 46 requiring the number of monitors to not be any greater than the number of mirrors required for the fields of vision covered by the CMS. Prototypes of CMS have become available in the latter end of 2018.

Moving to a next generation of cab design to improve direct vision will take a longer timescale than other vision measures because it is inter-linked with the bus front end design measure (see section 0), and subject to the same lead times for development. The vision roadmap is shown in Table 4.

Table 4: Roadmap for improved vision

	Direct Vision[4]	Enhanced Indirect Vision	Class II CMS	Blind spot mirrors	Blind spot CMS	Reversing CMS	Front & nearside information systems
Prototype (test method development)	n/a	2019	2018	2018	2019	2018	2018
Preferred (best practice / first to market)	2019	2020	2020	n/a	2020	n/a	2020
Required (production 3+ models)	2021	2024	2021	2019 (only to 2020*[5])	2021	2019	2024

This roadmap assumes clear and effective market signals to industry and represents the earliest possible opportunities for implementation. This is based on industry liaison throughout the research programme, and agreement of the timelines with manufacturers in workshop in July 2018.



[4] The requirements for driver assault screens, including angle of glazing, and incorporated into the bus vision standard.

[5] Blind spot mirrors will only be required on new build, refurbishment and repair for 2019-2020. Thereafter in 2021 they will not be required and will be replaced by blind spot CMS.

5.3.3 *Scope of vehicles to be equipped*

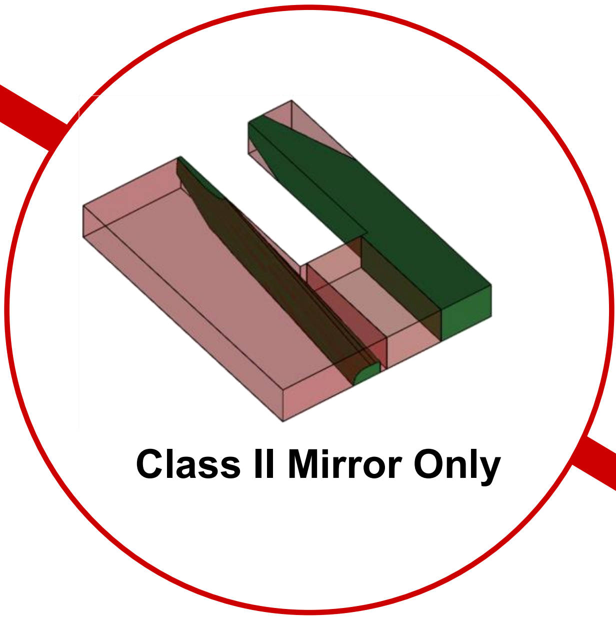
Most features relating to direct vision such as A-pillar position and thickness will be inherent in the design of the vehicle such that changes can only be applied to new vehicles.

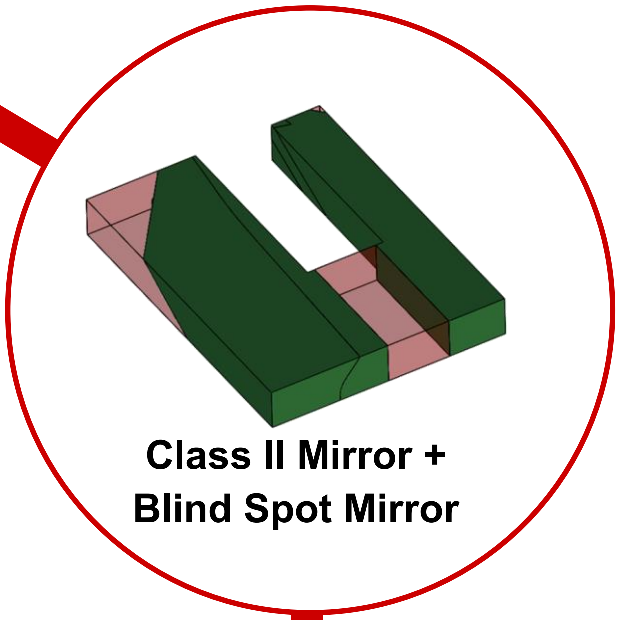
Other systems such as camera systems and alert systems may offer scope for retrofit as well as new build. No decisions have yet been taken by TfL regarding retrofit since this is still under feasibility review; all requirements currently relate to new build buses only.

5.3.4 *Calls for innovation*

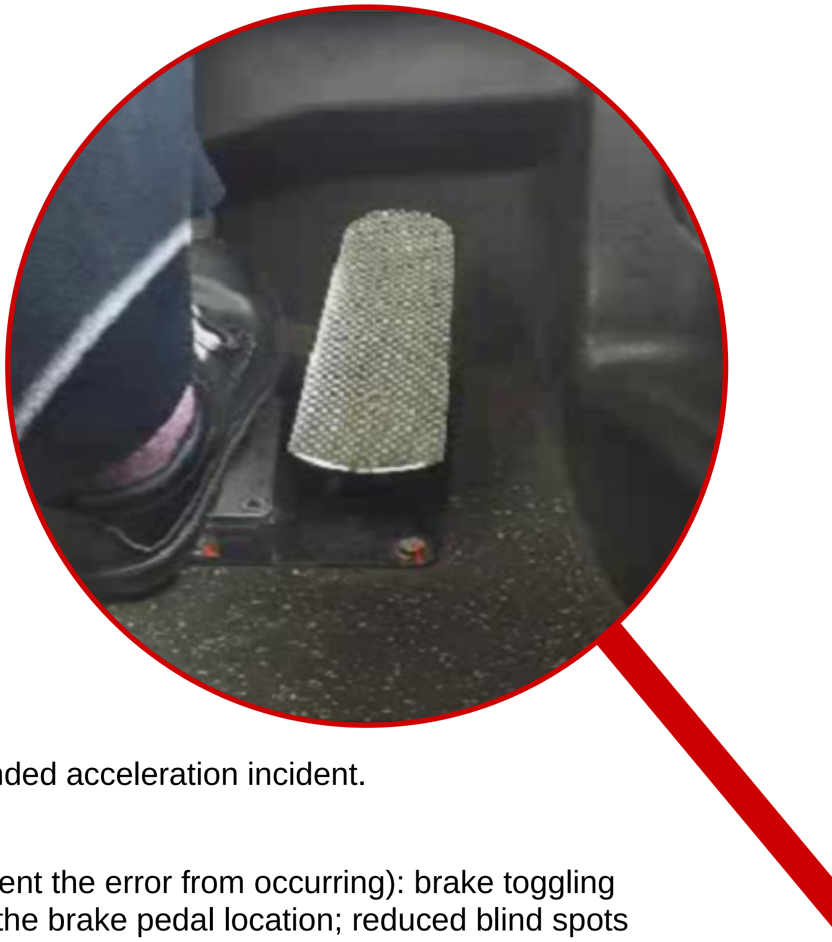
To be sure of how the Human-Machine Interface (HMI) is specified for CMS, particularly regarding placement of cameras and screens, TfL is calling for delivery partners for further research. This might take the form of a simulator and/or road trial.

TfL will also be considering some technical feasibility studies and proof of concept trials or testing to define performance thresholds for forward and nearside Blind Spot information signal, Warning and intervention (BSW) systems.





5.4 Pedal Application Error



5.4.1 System definition

A pedal application error occurs when the driver mistakenly presses the accelerator pedal instead of the brake pedal. It can be unintended acceleration or pedal confusion. 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.

There are number of potential solutions:

- Foot misplacement (to help prevent the error from occurring): brake toggling to refresh the brains memory of the brake pedal location; reduced blind spots to reduce the need for twisting in the seat; pedal standardisation.
- Recovery (to help the driver recover control in a long duration incident): a light indicator to the driver of when the accelerator is being heavily pressed; an engine type sound played to the driver to indicate the change of acceleration for quiet running vehicles.
- Intervention (to automatically intervene to avoid a collision): AEB systems typically have a logic that prevents operation if the driver gives a strong acceleration input, but this could be adapted to allow AEB intervention in the case of pedal application error.

5.4.2 Availability of the system

Brake toggling can be implemented via existing interlocks and brake system logic. Light indicators are relatively easy to add to a dashboard, particularly where there is an electronic display panel.

Pedal positioning and design are not currently standardised but could be. This may create some engineering challenges in bus designs and needs to fall within the current ISO 16121 standard[6]. Thus, best practice may be available early but wider

[6] ISO (2012). Road vehicles — Ergonomic requirements for the driver's workplace in line-service buses (ISO 16121-1:2012). International Standards Organisation, Geneva.

application across the market may take longer. Revised pedal layouts/control mechanisms have been proposed in prototype form before but are not available in production. However, these could significantly change the way drivers control a vehicle and this has been ingrained in drivers over many years. There is, therefore, a risk of unintended consequences that would require thorough research and development, likely to delay first introduction by some years.

AEB based mitigation is likely to be available on a comparable time frame to the core AEB function. However, any mitigation system based on detection of pedal confusion from characteristics of the incident (sequences of events, pedal application rates etc) will take significant time to develop, if ultimately feasible at all. The roadmap for the pedal confusion prevention solutions is shown in Table 5.

Table 5: Roadmap for pedal confusion prevention

	Brake toggling	Pedal layout standardisation	Accelerator light system	Pedal acoustic feedback	AEB logic
Prototype (test method development)	2018	2019	2018	2019	2019
Preferred (best practice / first to market)	2019	2020	n/a	2019	2020
Required (production 3+ models)	2021	2021	2019	2021	2024

The above assumes clear and effective market signals to industry and represents the earliest possible opportunities for implementation. This is based on industry liaison throughout the research programme, and agreement of the timelines with manufacturers in workshop in July 2018.

5.4.3 Scope of vehicles to be equipped

Brake toggling solutions can be for new build buses or can be retrofitted if there is a halt brake / bus stop brake already fitted to the vehicle. No decisions have yet been taken by TfL regarding retrofit since this is still under feasibility review; all requirements currently relate to new build buses only.

The remaining systems are for new build buses only.

5.4.4 Calls for innovation

During discussion with industry there has been some discussion of a pedal force intervention for the accelerator pedal. TfL is calling for a delivery partner to help with an evaluation of such a system.

5.5 Runaway Bus Prevention

5.5.1 System definition

Runaway bus incidents occur in rare circumstances if the driver leaves control of the bus without the parking brake applied. Systems are available that warn the driver if the door is opened, or in some cases if the driver's seat is not occupied, and the parking brake is not applied. While offering potential benefits, these still rely on the driver seeing and understanding the warning and taking the correct action.

It is technically feasible to design an interlock system that ensures the parking brake is automatically applied whenever the driver's seat is carrying no weight.

5.5.2 Availability of the system

Aftermarket systems are available now that can be integrated into new build vehicles. Alternatively, once brake system suppliers launch their electronic park brake solutions, the logic could be easily programmed in.

Installing the systems as either new build or retrofit requires detailed work with the brake system suppliers, so that the relevant compliance is maintained. Any additional compliance check can require time to achieve, so the system is not feasible for immediate requirement in 2019. The roadmap is shown in Table 6.

Table 6: Roadmap for runaway bus prevention

	Runaway bus prevention
Prototype (test method development)	2017
Preferred (best practice / first to market)	2019
Required (production 3+ models)	2021

The above assumes clear and effective market signals to industry and represents the earliest possible opportunities for implementation. This is based on industry liaison throughout the research programme, and agreement of the timelines with manufacturers in workshop in July 2018.

5.5.3 Scope of vehicles to be equipped

The system could be for both new build buses and retrofit to the existing fleet. No decisions have yet been taken by TfL regarding retrofit since this is still under feasibility review; all requirements currently relate to new build buses only.


No loading
Mon - Sat
7am - 7pm
GERRATTS

7 Partner Assist

Partner assist measures are concerned with helping the other road users involved, the collision partners, to avoid the collision.

7.1 Acoustic Conspicuity

7.1.1 System definition

A solution for quiet running hybrid and electric vehicles has been defined as an audible warning, active at low speed, intended to replace engine noise as a cue to VRU that a vehicle is approaching. UNECE Regulation 138 defines an Acoustic Vehicle Alerting System (AVAS) which is required to emit a constant noise at speeds between 0 and 20 km/h that falls within minimum and maximum volume limits, and at least one component of which varies with speed. The vehicle may optionally emit a sound while stationary. This will form a mandatory part of EU type approval from 2019 for new type approvals and from 2022 for all new vehicles sold.

7.1.2 Availability of the system

If bus manufacturers use the European type approval, then their buses will have to have AVAS from 2019/2022. If the manufacturers use National Small Series this is not yet a requirement, but TfL are bringing this requirement into their specification. However, the hardware and software associated with the system is not particularly complicated and there are many other vehicle types bringing out AVAS. There are retrofit solutions currently available too; however, these might not have the capability to have the urban bus sound as prescribed by TfL.

Table 7-1: Roadmap for acoustic conspicuity

	AVAS
Prototype (test method development)	2018
Preferred (best practice / first to market)	n/a
Required (production 3+ models)	2019

The above assumes clear and effective market signals to industry and represents the earliest possible opportunities for implementation. This is based on industry liaison throughout the research programme, and agreement of the timelines with manufacturers in workshop in July 2018.

7.1.3 Scope of vehicles to be equipped

This requirement is aimed at new build buses.

There are some retrofit systems available, but they might not have the ability to emit the urban bus sound required by TfL and might not have the ability to be updated. No decisions have yet been taken by TfL regarding retrofit since this is still under feasibility review; they are strongly considering the fitment to the existing fleet of quiet running buses.

7.1.4 Calls for innovation

There is relatively minimal control of what sound should be emitted. TfL will be developing an urban bus sound for use on all buses across London, to minimise the risk of different models all sounding different. TfL is calling for bus manufacturers to contribute their experience and to help develop this urban bus sound. It is important to note that the AVAS will also be required to have the ability to be updated if the sound should be changed at some point in the future life of the bus.

7.2 Visual Conspicuity

7.2.1 System definition

The system can be defined as “any visual feature or system that is able to increase the probability that a pedestrian will successfully recognise the risk represented by an approaching bus such that they choose not to cross in front of it”. It could include:

- High contrast features.
- Altering lighting configuration.
- Altering colour / partial colour / exterior fittings colour.
- Switching off daytime running lamps when stationary to distinguish between stationary and moving buses.
- Saloon lights / colour.

Additional top marker lights and additional retroreflective marker tape were two solutions that were investigated in the research but were not found to offer a significant improvement for the unimpaired average population.

7.2.2 Availability of the system

At present, there are no requirements set by TfL for visual conspicuity.

7.2.3 Scope of vehicles to be equipped

New build buses.

7.2.4 Calls for innovation

TfL is calling for innovation to develop attention conspicuity measures for the front and nearside of buses. This means bringing people’s attention to the presence of a bus before they commit to crossing the road for example.


BUS STOP
Denmark Street
towards Holborn
or Warren Street
24 hour 14
19
24 hour 24
29
38
24 hour 176
Night Bus N5
Night Bus N19
Night Bus N20
Night Bus N29
Night Bus N38
Night Bus N41 N279
brakes
DAF

8 Partner Protection

Partner protection measures are concerned with reducing the severity of injuries for road users outside the bus in a collision.

8.1 VRU Frontal Crashworthiness

8.1.1 System definition

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. There are several relevant solutions:

- Bus front end design: changes to the geometry of the bus front in order to influence pedestrian kinematics during impact and can include a backwards rake and more rounded corners.
- Impact protection: energy absorption can be improved by changing the stiffness of the frontal structures; wiper protection relates to moving the wipers up to the top of the screen or providing protection for them if bottom mounted.
- Mirror strike protection: the repositioning of mirrors, away from a hazardous height, through their replacement with a CMS.

The frontal design of a bus is a complex compromise involving many factors. Thus, the above must be achieved while at least not compromising direct or indirect vision and preferably improving it (see section 5.3), and while respecting constraints on overall length, driver positioning, entry and exit doors etc.

8.1.2 Availability of the system

There is some variation of frontal shape already present within the market and, for example, some manufacturers mount windscreen wipers above the windscreen.

A complete re-design of the front end of the bus can realistically only be implemented in a new model. Bus models will commonly have a lifespan of 8-10 years and the lead time is at least 3 years.

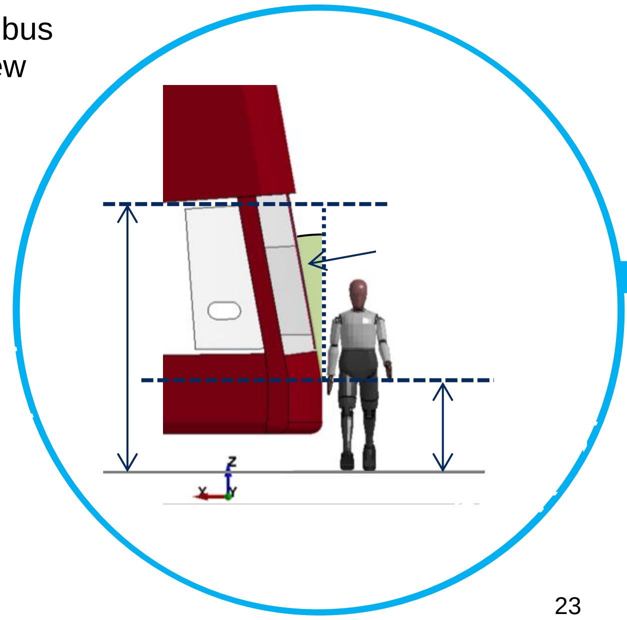


Table 8-1: Roadmap for bus front end design

	Minimum geometry	Optimised geometry	Energy absorption	Wiper protection	Class II CMS
Prototype (test method development)	2018	2020	2019	2018	2018
Preferred (best practice / first to market)	2019	2022	2021	2019	2020
Required (production 3+ models)	2021	2024	2024	2021	2021

The above assumes clear and effective market signals to industry and represents the earliest possible opportunities for implementation. This is based on industry liaison throughout the research programme, and agreement of the timelines with manufacturers in workshop in July 2018.

8.1.3 Scope of vehicles to be equipped

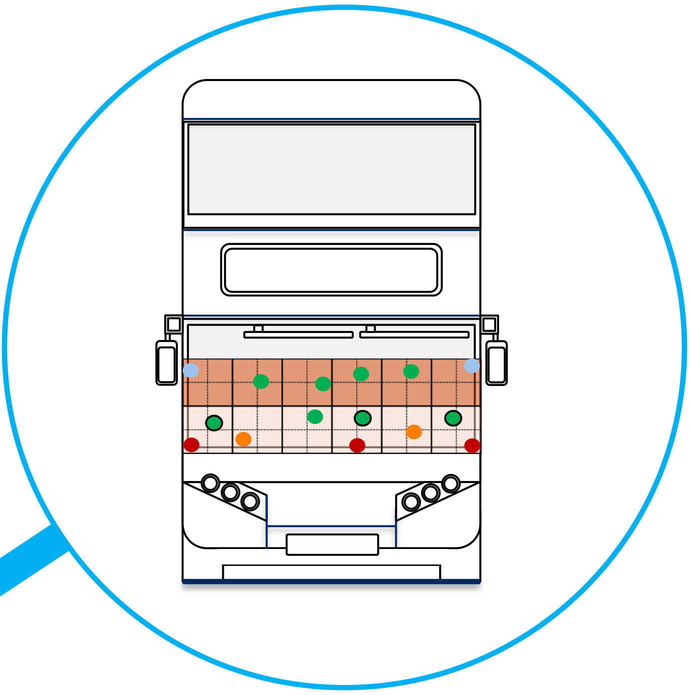
In most cases, the structures required to improve pedestrian protection in the event of a collision are a fundamental part of the design of the vehicle, so measures in this area could only be applied to new vehicles.

The exception to this is the replacement of Class II mirrors with Class II CMS which may offer scope for retrofit as well as new build. No decisions have yet been taken by TfL regarding retrofit since this is still under feasibility review; so all requirements currently relate to new build buses only.

8.1.4 Calls for innovation

TfL is also calling for further research into the bus front end design. The research program so far has considered head impacts of pedestrians, but this will be extended to consider leg protection for pedestrians and cyclist protection too.

TfL is also calling for innovative solutions that will help protect against run-over for use at the front of buses.



9 Occupant Protection

9.1 Occupant Friendly Interiors

Occupant protection measures are concerned with reducing the severity of injuries for people on board the bus.

9.1.1 System definition

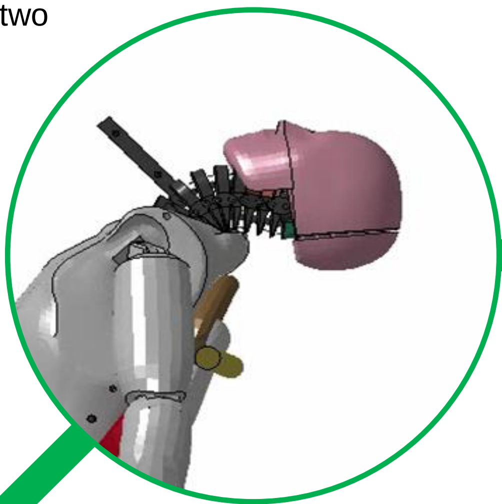
Considering bus passenger injuries, the majority of the more severe casualties and fatalities occur in collisions, but a large number of slight injuries occur in non-collision incidents such as harsh braking. The basic premise of an 'occupant friendly interior' is that structures that the occupant might come into contact with when the bus manoeuvres and they fall, for example, should be designed in a way that minimises the chances of injury. 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.

This assessment scheme harmonises with a forthcoming amendment to Reg 107[7] that will require additional guards for unprotected seats, but also extends and adds to this requirement.

9.1.2 Availability of the system

Many models on the existing London fleet have been reviewed and they show a variety of good designs for occupant protection. An optimised solution will take time to implement because seating and pole layouts are strongly interrelated with each other and with other key metrics around passenger capacity, speed of loading etc. For example, the poles remain a dilemma in that they provide protection against falling, but once a fall is in progress then they can pose a risk of injury; hence their careful positioning is the key area for development.

The requirements developed have been split into two levels by score. Level 1 is likely to mean changes around the middle door area including guards in front of seats behind the wheelchair area, and modifications to the guard for seats behind middle doors. Level 2 is a more demanding score requiring changes throughout the whole bus for handrails, restraints and general hazards. It may also involve some seats having higher backs.



[7] https://www.unece.org/fileadmin/DAM/trans/doc/2015/wp29grsg/ECE-TRANS-WP29-GRSG-2015-34e.pdf

Table 9-1: Roadmap for occupant friendly interiors

	Level 1 requirements	Level 2 requirements
Prototype (test method development)	2018	2018
Preferred (best practice / first to market)	2019	2020
Required (production 3+ models)	2021	2024

The above assumes clear and effective market signals to industry and represents the earliest possible opportunities for implementation. This is based on industry liaison throughout the research programme, and agreement of the timelines with manufacturers in workshop in July 2018.

9.1.3 Scope of vehicles to be equipped

The occupant friendly interior requirements are intended for new vehicles where they can be designed in from the start, with a minimum of compromise.

9.1.4 Calls for innovation

Improvements to interior design are complex and TfL is calling for further innovation in a number of areas:

- Innovate seat design to better protect against head impact on the back of the seat in front, and against neck injury when the seat occupant moves into the seat back, but without compromising the seat weight.
- Innovate the design or material of grab poles and bars in order to reduce casualties.
- Resolve the issue of buggy toppling.

9.2 Slip Resistant Flooring

9.2.1 System definition

A slip resistant floor is one that can maintain a good level of friction between shoe and floor, despite the presence of lubricants such as water. There is now a minimum standard for the slip resistance of flooring to help protect against slips.

9.2.2 Availability of the system

There are examples of flooring on current London buses that meet the new minimum slip resistance standard, which has been selected based on both best practice and the UK Slip Resistance Group Guidelines.

Table 9-2: Roadmap for slip resistant flooring

	Slip resistant flooring
Prototype (test method development)	2017
Preferred (best practice / first to market)	n/a
Required (production 3+ models)	2019

The above assumes clear and effective market signals to industry and represents the earliest possible opportunities for implementation. This is based on industry liaison throughout the research programme, and agreement of the timelines with manufacturers in workshop in July 2018.

9.2.3 Scope of vehicles to be equipped

The slip resistant floor standards are for new build buses.

10 Bus Safety Road Map

			2018	2019	2020	2021	2022	2023	2024	2025	2026	onwards
Driver Assist	**Intelligent Speed Assistance (ISA)**	Standalone mandatory	Required									
Driver Assist	**Advanced Emergency Braking (AEB)**	Car, Pedestrian & Cyclist partners			Preferred				Required			
Driver Assist	**Runaway Bus Prevention**	Interlock system		Preferred		Required						
Driver Assist	**Pedal Application Error** – Foot placement	Brake toggling		Preferred		Required						
Driver Assist	**Pedal Application Error** – Foot placement	Pedal standardisation			Preferred	Required						
Driver Assist	**Pedal Application Error** – Recovery	Pedal indicator lights		Required								
Driver Assist	**Pedal Application Error** – Recovery	Pedal acoustic feedback		Preferred		Required						
Driver Assist	**Pedal Application Error** – Intervention	AEB logic			Preferred				Required			
Driver Assist	**Vision –** Direct & indirect vision standard	Direct vision		Preferred		Required						
Driver Assist	**Vision –** Direct & indirect vision standard	Enhanced indirect vision			Preferred				Required			
Driver Assist	**Vision –** Direct & indirect vision standard	Class II CMS			Preferred	Required						
Driver Assist	**Vision –** Direct & indirect vision standard	Blind spot Mirrors		Required								
Driver Assist	**Vision –** Direct & indirect vision standard	Blind spot CMS			Preferred	Required						
Driver Assist	**Vision –** Direct & indirect vision standard	Reversing CMS		Required								
Driver Assist	**Vision –** Direct & indirect vision standard	Front & Nearside Warning Systems			Preferred				Required			
Driver Assist	**Vision** – Internal obscuration	Driver assault screens		Required								
Partner Assist	**Acoustic Conspicuity**	Acoustic Vehicle Alerting System		Required								
Partner Protection	**VRU Frontal Crashworthiness** – Bus front end design	Minimum geometry		Preferred		Required						
Partner Protection	**VRU Frontal Crashworthiness** – Bus front end design	Optimised geometry					Preferred		Required			
Partner Protection	**VRU Frontal Crashworthiness** – VRU impact protection	Energy absorption				Preferred			Required			
Partner Protection	**VRU Frontal Crashworthiness** – VRU impact protection	Wiper protection		Preferred		Required						
Partner Protection	**VRU Frontal Crashworthiness** – Mirror strike protection	Class II CMS			Preferred	Required						
Occupant Protection	**Occupant Friendly Interiors** – Visual inspection & design	Level 1 requirements		Preferred		Required						
Occupant Protection	**Occupant Friendly Interiors** – Visual inspection & design	Level 2 requirements			Preferred				Required			
Occupant Protection	**Occupant Friendly Interiors –** Slip protection	Surface friction requirements		Required								

A summary of the timelines per safety measure has been compiled into a roadmap with a intention of providing 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.

An initial consultation roadmap was produced at the end of 2017 to stimulate the discussions with the bus industry. Multiple bus manufacturers and suppliers have fed into the consultation, and the timelines presented in the roadmap are based on their agreements in a stakeholder workshop held in July 2018. This updated version 2.0 now summarises the overall plan for TfL's implementation strategy, based on those technical discussion with the bus industry.

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 to remain relevant. The Euro NCAP (European New Car Assessment Program) roadmap for passenger car safety was used as the model approach. The roadmap is a rolling document and will be updated approximately every 1-3 years in line with updates from TfL regarding their future plans. This research was completed in 2018. The detailed specification, assessment procedures and guidance notes have been incorporated into the Transport for London specification for buses, which is a continuously updated document to keep pace with the latest technological and research developments, as is the roadmap. This report is not the specification/roadmap for a bus and should not be used as such. Bus operators, manufacturers, and their supply chain should consult with TfL for the specification/roadmap.

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.

- Preferred (dashed lines) – refers to a best practice approach, it is not required but might gain preference in procurement. This represents the first to market.
- Requirement (solid lines) – refers to a minimum or mandatory requirement. This would represent a wider adoption throughout the London bus market, potentially 3+ models.

The coloured lines refer to TfL's roadmap according to their section:

Driver Assist | **Partner Protection**

Partner Assist | **Occupant Protection**

The years indicate the year in which the preferred/required safety measure will be on the road. For manufacturers and operators, it is important to note that this is not the tender, which may come 6-9 months prior to the buses becoming operational.


IVECO
Caution
This bus pulls in frequently

11 Regulatory Developments

Amendment to Reg 107 related to occupant friendly interiors has already been mentioned in section 9.1, and the AVAS requirements of Reg 138 were described in section 7.1. There are also major new requirements proposed by the European Commission for an update to the General Safety Regulation that must be considered. In each case TfL might adopt the regulated safety measure ahead of the regulatory timescales or might raise the standards higher than regulation. Manufacturers are advised to keep monitoring the regulatory developments so that they are prepared for any new TfL requirements that might be associated.

In May 2018 the European Commission adopted a proposal for multiple new safety measures to be incorporated into type approval legislation for the safety of motor vehicles, protection of the vehicle occupants, and protection of vulnerable road users. The formal process for this is still ongoing, with full adoption yet to be achieved, and regulatory texts still in development. The first requirements will come into force 3 years after full adoption of the proposals. The measures concerned with buses and their anticipated (although yet to be formalised) requirement dates are summarised in the table below.

It is notable that many of these requirements are already being adopted by TfL ahead of the regulatory requirements. Wherever possible in the research programme the forthcoming regulation work has been considered in the development of TfL's requirements in order to harmonise, or at least to avoid conflict. However, since many areas of the regulations are not yet developed this is difficult, although there is opportunity for TfL's research and assessment protocol development to be fed into the development of the regulatory texts.

The proposed regulation provides a list of areas for which technical requirements would be laid down in Commission delegated acts, which can be vetoed by the Parliament or the Council. These are looking much further to the future design of buses, and these specific requirements relate to systems:

- To replace the driver's control of the vehicle.
- Systems to provide the vehicle with real-time information on the state of the vehicle and the surrounding area.
- Driver-readiness monitoring systems (which assess whether the driver is in a position to take over the driving function).
- Event data recorders for automated vehicles.
- A harmonised format for the exchange of data, for instance, for multi-make vehicle platooning.

Table 11-1: Summary of anticipated regulatory developments

Area	Safety measure	System description	New models	All models	TfL requirements status notes
Driver Assistance	Intelligent Speed Assistance (ISA)	Based on observation of road signs, signals and markings or via electronic map data would alert the driver of exceeding the speed limit by providing haptic feedback through the accelerator pedal	2022	2024	TfL already require a mandatory version of ISA; future developments will need to harmonise with the regulation
Driver Assistance	Direct vision	Cabin design with direct vision that would enable the driver to see vulnerable road users directly from the driver's seat without using mirrors or cameras	2026	2029	TfL is already making direct vision requirements ahead of the regulation
Driver Assistance	Reversing detection	Help avoid collisions with people and objects behind the vehicle by making the driver aware of them	2022	2024	London already has a large proportion of the fleet fitted with reversing CMS, and TfL is adopting requirements ahead of the regulation
Driver Assistance	Pedestrian and cyclist collision warning	An onboard system to detect and inform the driver of the presence of pedestrians and cyclists in the close-proximity forward blind-spot of the vehicle and, if deemed necessary based on manufacturer strategy, warn the driver of a potential collision.	2022	2024	TfL is already making these warning requirements slightly ahead of the regulation
Driver Assistance	Blind spot information system	Blind Spot Information System (BSIS) means a system to inform the driver of a possible collision with a bicycle towards the near side.	2022	2024	TfL is already making these information system requirements slightly ahead of the regulation
Driver Assistance	Alcohol interlock installation facilitation	Enable motor vehicles to be fitted with an alcohol interlock device using a standardised interface	2022	2024	
Driver Assistance	Driver drowsiness and attention warning	Alert the driver if, through vehicle system analysis, it assesses the driver's alertness as being insufficient	2022	2024	TfL already has a programme of work investigating fatigue issues for bus drivers. No requirements yet.
Driver Assistance	Advanced driver distraction warning	Assess the level of the driver's visual attention to the traffic situation	2024	2026	
Driver Assistance	Tyre Pressure Monitoring System	Evaluate the pressure of the tyres or the variation of pressure over time and transmit corresponding information to the user while the vehicle is running	2022	2024	
Driver Assistance	Event Data Recorder (EDR)	A system with the only purpose of recording and storing critical crash-related parameters and information shortly before, during and immediately after a collision	2026	2029	
Partner Assist	Acoustic Vehicle Alerting System (AVAS)	System for quiet running vehicles to alert VRUs by emitting a sound	2019	2022	TfL is adopting these requirements on all models ahead of regulation.
Partner Assist	Emergency Stop Signal	Activate rapidly flashing stop lamps to indicate to other road users behind the vehicle that the driver is suddenly braking	2022	2024	

12 Additional calls for Innovation

TfL has also identified some other areas where the bus manufacturers, suppliers and operators are encouraged to innovate.

12.1 Low bridge avoidance

Buses can occasionally suffer collisions with low bridges, and these typically occur if there is a route alteration or if a double decker is driven by a driver more used to a single decker. It should be feasible to detect and warn or intervene to protect against these potentially high severity outcome incidents. This could be via an AEB type system based on sensors on the bus, or via a location-based GPS style system.

12.2 CCTV, telematics and event data recording

TfL is currently working to review and update its CCTV specification used in the contracting of bus services. Alongside this there is interest in developing a telematics specification to record driving behaviour data, based on evidence from the car industry that such systems can have an effect on improving driving style and consequently reducing claims. Similarly, Event Data Recorder (EDR) requirements could be developed to record relevant collision forces and data feeds from the vehicle CAN in order to inform the liability and claims process, as well as to inform future safety measure developments.

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