LONDON BUS SERVICES LIMITED

Specification for new buses: Attachments

Version 1.1

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1 Preface

This protocol covers the assessments to be carried out for safety features fitted to TFL buses.

Where a vehicle manufacturer perceives that a particular feature should be changed, this should be raised by the manufacturer with the competent authority (TfL) assessor present at the assessment, or in writing to the competent authority (TfL) Nominated Officer in the absence of an assessor. The competent authority (TfL) will assess the problem based on their judgment and provide instruction to the assessment facility.

Vehicle manufacturers are barred from directly or indirectly interfering with the assessment and prohibited from altering any characteristics that may impact the assessment, including but not restricted to vehicle setting, laboratory environment etc.

2 Disclaimer & Copyright

TfL has taken all appropriate caution to guarantee that the information contained in this protocol is correct and demonstrates the prevailing technical decisions taken by the organisation. In the occasion that a mistake or inaccuracy is identified, TfL retains the right to make amendments and decide on the assessment and future outcome of the affected requirement(s).

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Table of Contents

Attachment 24: Blind Spot Warning Assessment Protocol

1 Introduction

This document presents a procedure for objectively measuring the performance of Blind Spot information signal, Warning and intervention (BSW) systems.

1.1 Scope

This protocol applies to all new buses intended for service under contract to TfL that are passenger vehicles with a maximum mass exceeding 5 tonnes and a capacity exceeding 22 passengers. The passenger vehicles will be capable of carrying seated but unrestrained occupants and standing occupants. Such vehicles are categorised in the Consolidated Resolution on the Construction of Vehicles (R.E.3) as M3; Class I, Class II.

Note, this standard is intended for application in the UK where vehicles drive on the left hand side of the road. However, application to regions where vehicles drive on the right hand side can be achieved by reflecting all scenarios and references to left and right about the longitudinal plane of the vehicle (global X-axis).

1.2 Purpose

Over many years, blind spots have been identified as contributory factors in collisions between heavy goods vehicles (HGVs) and vulnerable road users (VRUs). The direct vision through the glazed areas of HGVs is such that, given their height from the ground, pedestrians and cyclists can be easily hidden in many areas that cannot be seen directly and in some areas that cannot be seen either directly or indirectly through the available mirrors.

The direct vision of buses is superior to that from most HGVs, though fewer mirrors are legally required on buses resulting in an inferior indirect vision field of view. In total the blind spot areas in close proximity to buses are smaller. However, collisions where pedestrians and cyclists are killed or seriously injured when positioned in close proximity to a moving bus do still occur.

Overall London buses present a much lower risk of cyclist fatality per bus km than HGVs do. However, the proportion of relevant fatalities that occur in collisions where the vehicle turned left and hit a cyclist at the nearside or front, thought to be a highly relevant manoeuvre for blind spots, is only slightly lower than that for HGVs.

By contrast, London buses present a much higher risk of pedestrian fatality per bus km than HGVs do. However, the proportion of those collisions that involve a vehicle moving off from rest and running over a pedestrian positioned immediately ahead of the vehicle, again thought to be a highly relevant manoeuvre for blind spots, is substantially less than for HGVs.

Direct and indirect vision will be factors in the differences between these vehicle types, but it is clear that better vision alone does not eliminate risk. Drivers must be attentive, looking in the right direction at the right time during potentially demanding driving situations and, having identified a potential collision, take the correct action. Blind spot information signal, warning systems therefore have a role to play in helping ensure the driver pays attention to the presence of a pedestrian or cyclist in close proximity to a bus and assisting the driver with taking the correct action if a collision is imminent.

A regulation defining minimum standards for such systems is under development as part of a UN ECE Regulation. However, it will not initially be mandatory, may only apply to HGVs and not buses, is a minimum pass/fail standard and only covers information signal and not necessarily warning or intervention systems.

The aim of this protocol is to provide objective assessments that can be used to enforce minimum standards even where the forthcoming regulation does not apply and to encourage performance over and above those minimum standards.

It should be noted that this protocol only covers collision situations related to low speed, close proximity manoeuvring. It does not consider forward collision warnings of the type relevant at higher speeds with the vehicle travelling in a straight line such as those scenarios covered by TfL’s AEB testing and assessment protocol.

It should further be noted that this protocol does not require or reward automated emergency braking systems in the low speed close proximity manoeuvres that are in scope.

2 Normative References

The following normative documents, in whole or in part, are referenced in this document and are indispensable for its application. For dated references only the edition cited applies. For undated references the latest edition of the referenced document (including any amendments) applies.

- Directive 2007/46/EC of the European Parliament and of the Council establishing a framework for the approval of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles.
- Regulation (EU) 2018/858 of the European Parliament and of the Council of 30th May 2018 on the approval and market surveillance of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles, amending Regulations (EC) No 715/2007 and (EC) No 595/2009 and repealing Directive 2007/46/EC
- UNECE Regulation 107 Uniform provisions concerning the approval of category M_2 or M_3 vehicles with regard to their general construction
- Euro NCAP Test Protocol AEB VRU Systems Version 2.0.1 August 2017
- Articulated Pedestrian Target Specification document version 1.0.
- Bicyclist Target Specification document version 1.0.
- UNECE Regulation 10. Uniform provisions concerning the approval of vehicles with regard to electromagnetic compatibility
- BS EN 50498:2010 Electromagnetic compatibility (EMC). Product family standard for aftermarket electronic equipment in vehicles.
- ISO 11452-9 'Component test methods for electrical disturbances from narrowband radiated electromagnetic energy - Part 9: Portable transmitters'
- ISO 11451-3 'Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 3: On Board Transmitter Simulation'
- UNECE Regulation 61 Uniform provisions on the external projections of commercial vehicles
- Commission Regulation (EU) No 1230/2012 implementing Regulation (EC) No 661/2009 of the European Parliament and of the Council with regard to type-approval requirements for masses and dimensions of motor vehicles and their trailers and amending Directive 2007/46/EC of the European Parliament and of the Council.
- ISO 612:1978 Road Vehicles – Dimensions of motor vehicles and towed vehicles – terms and definitions.
- ISO 15006: 2011. Ergonomic aspects of transport information and control systems – specifications for in-vehicle auditory presentation
- ISO 15008: 2009. Road vehicle – Ergonomics aspects of transport information and control systems – Specification and test procedure for in-vehicle visual presentation

- ISO 15998:2008 Earth moving machinery – Machine control systems (MCS) using electronic components – performance criteria and tests for functional safety
- ISO 16001: 2008. Earth moving machinery. Object detection systems and visibility aids
- ISO 15037-2: 2006: *Road Vehicles – Vehicle dynamics test methods - General conditions for heavy vehicles and buses*

3 Definitions

For the purpose of this Protocol:

- **Accelerator heel point (AHP) -** a point on the shoe located at the intersection of the heel of shoe and the depressed floor covering, when the shoe tool is properly positioned. (Essentially, with the ball of the foot contacting the lateral centre line of the undepressed accelerator pedal, while the bottom of the shoe is maintained on the pedal plane). As defined in SAE J1516, SAE J1517 and SAE J1100.
- **Approval Authority** - the body within TfL that certifies that a bus is approved for use in the TfL fleet and assigns its score under the bus safety standard for use in procurement processes.
- **Aftermarket system** - a BSW system that is fitted to the vehicle after it has been registered and delivered for the first time, by agencies other than the vehicle manufacturers or their authorised dealer.
- **Blind spot** - the volume of space around the test vehicle that cannot be seen by the driver either through the glazed areas of the vehicle cab or through the indirect vision devices installed on the vehicle.
- **Blind Spot information signal, Warning and intervention (BSW) system** - a complete system, encompassing both the defined blind spot safety functions and enabling technologies, that informs the driver of a VRU in close proximity to the vehicle, warns the driver of an imminent collision with a VRU and/or intervenes directly with the drive controls to prevent a collision.
- **Blind spot safety function** – these functions are defined by the action that the enabling technologies take to either improve the chances of a driver acting appropriately should a VRU be in the vehicle blind spot or to automatically avoid a collision should the driver fail to take the appropriate action. They include:

  (a) **VRU proximity information signal** - a signal informing the driver that a VRU has been detected in close proximity to the vehicle. A proximity information signal (which may be referred to as an information signal), is a medium urgency signal that reflects the fact that the driver may or may not be aware of the presence of the VRU and that there may or may not be an imminent risk of collision.

  (b) **VRU collision warning signal** - a signal issued to the driver where an imminent collision between the VRU and the vehicle is calculated as likely. Such a system shall not warn the driver of the simple presence of a VRU in close proximity if the trajectories of each are such that a collision is not imminent. A collision warning is a high urgency signal that warns the driver of the vehicle that a collision is imminent.

  (c) **Motion inhibit** - a system that prevents a vehicle from moving off from rest when a VRU is located in front of the vehicle is at risk of an imminent collision. The system may achieve the function through intervention in throttle, gear selection or braking. The system shall be type approved for use by the Original Equipment Manufacturer (OEM) of the vehicle.

- **Dealer fit system** – a BSW system that is fitted as a standard component to the vehicle after production (i.e. not integrated in the original vehicle design). However, the installation of the device is approved by the manufacturer of the vehicle and fitted by its authorised dealers prior to delivery and registration.
- **Enabling technologies** - the technologies that enable the blind spot safety function through the combination of sensor components, decision-making algorithms and the components utilised to implement the blind spot safety function. Sensor and vehicle components may be used for multiple purposes (e.g. cameras may also be used by camera monitoring systems replacing external mirrors or for CCTV recording purposes) or a single function may require more than one sensing technology (e.g. the use of both camera and RADAR sensors in a process known as sensor fusion).
- **Human Machine Interface (HMI)** - the part of a BSW system that interacts with the driver and includes controls and settings for activating or adjusting the application as well as the means by which information and warning signals are communicated from the system to the driver.
- **Horizontal field of view angle** - the angle between the longitudinal plane of the test vehicle and the sightline
- **Original Equipment Manufacturer (OEM) system** - a BSW system that is integrated into the design of the vehicle and is fitted in the factory.
- **Motion inhibit over-ride** - a manual over-ride function that, when applied, deactivates the motion inhibit blind spot safety function
- **RADAR** - radio detection and ranging. A sensor component that uses radio waves to detect the range and positions of objects.
- **Reference eye point** - a point representing the centre point of the driver's left and right eyes and offset from the AHP by [678]mm in the X axis and [1163.25]mm in the Z axis. This is the point from which the sightline originates.
- **Signal** - the transmission of an identifiable alert to a bus driver through the HMI notifying them to the hazards that may be caused by the interaction of their vehicle with a VRU. Signals may be transmitted to the driver by the HMI through a number of different signal modes.
- **Signal mode** - the method of transmitting a signal to a driver and consisting of four key modes including: audible (tonal), audible (speech), visual or haptic.
- **Sightline** - a line parallel to the XY plane that passes through the reference eye point and is angled according to a specified horizontal field of view angle
- **Standardised environmental clutter** - the minimum set of roadside furniture (described below), that is positioned to simulate a realistic environment that has the potential to affect the performance of the sensors often used for the enabling technology.
    a) **Advertising hoarding** - A standard advertising hoarding measuring approximately 2 m tall by 1 m wide. A life size image of the Euro NCAP adult pedestrian dummy shall be displayed on the advertising hoarding (Figure 1). The image shall be positioned such that the dummy faces towards the test vehicle trajectory. The image and sign shall be

positioned such that the lower edge of the dummies feet is as close to the ground as possible and no more than 200 mm from the ground.

Figure 1: Example of the standard advertising hoarding and image

b) **Traffic sign** - a 30mph speed limit sign complying with the C14 standard of the Vienna Convention on Road Signs and Signals. It shall be mounted on a pole such that the lowest point of the sign shall be located 2 m vertically above the test track surface.

c) **Railing** - A typical city kerbside railing that shall be simulated using temporary metal crowd control barriers (Figure 2). These metal crowd control barriers shall constructed from a metal easily detected by RADAR. The height of the barrier shall be 1115 mm ± 5 mm. The height of the upper surface of the horizontal rail at the bottom shall be 255 mm ± 5 mm. The diameter of the vertical rail shall be no less than 10 mm and the distance between the vertical rails (from centre to centre) shall be 125 mm ± 5 mm. The feet of the railing shall extend laterally by no more than 200mm from the centre-line of the railing.

Figure 2: Example of a temporary metal crowd control railing

- **Test Service** - the organisation undertaking the testing and certification of the results to the Approval Authority.

- **Test Target** - a test dummy that accurately represents the characteristics of the relevant VRU, as seen by the relevant sensing technologies used by BSW. A range of specific test targets are defined[1]:
  a) **EBT: Euro NCAP Bicyclist and bike Target** - means the bicyclist and bike target as specified in the Euro NCAP Bicyclist Target Specification document version 1.0.
  b) **EPTa: Euro NCAP Adult Pedestrian Target** - means the adult pedestrian target as specified in the Euro NCAP Articulated Pedestrian Target Specification document version 1.0.
  c) **EPTc: Euro NCAP Child Pedestrian Target** - means the child pedestrian target as specified in the Euro NCAP Articulated Pedestrian Target Specification document version 1.0.
- **Test Vehicle (TV)** - the vehicle under test according to this protocol.
- **Time to Collision (TTC)** - the time it would take for the vehicle to reach the point of collision if the speed and trajectory of the vehicle remained constant when calculated at any instant in time. At constant vehicle speeds, the TTC will always reduce over time. If speed is reduced, however, TTC increases and if sufficient braking is applied to avoid a collision then the TTC tends to infinity.
- **Vehicle length:** the distance in the X-axis between two points located at the foremost and rearmost aspect of the vehicle and measured in accordance with the definition contained in Commission Regulation (EU) no 1230/2012, when excluding the following components:
  a) Wiper and washer devices
  b) Front or rear marker-plates
  c) Lighting and light signalling devices
  d) Mirrors or other devices for indirect vision
  e) Watching and detection aids including RADAR
  f) Access ramps, retractable steps and lift platforms etc.
  g) Coupling and recovery towing devices for power driven vehicles
  h) Trolleybus current collection devices
  i) De-mountable spoilers
  j) Exhaust pipes
- **Vehicle width** - the distance in the Y-axis at the widest point of the vehicle and measured in accordance with the definition contained in Commission Regulation (EU) no 1230/2012, when excluding the following components:
  a) Mirrors or other devices for indirect vision
  b) Bulge in the tyre at the point of contact with the road
  c) Tyre failure tell-tale devices and pressure indicators

[1] ISO standards (ISO 19206) for these test targets are under development and once published should replace the references to the equivalent Euro NCAP standards

d) Side marker lamps, service door lighting and other side mounted lamps and retroreflectors

e) Access ramps, retractable steps and lift platforms etc.

f) Watching and detection aids including RADAR

g) Flexible mudguards

h) Snow chains

4 Reference system

4.1 Global Coordinate System

4.1.1 A global coordinate system (X,Y,Z), fixed relative to the Earth, shall be defined such that the global (X,Y,Z) axes are coincident with the local (x,y,z) axes of the Test Vehicle in its initial position (T_0). These shall be defined such that the X-axis points toward the front of the Test Vehicle, the Y-axis towards the left (nearside) and the Z-axis upwards, as shown in **Error! Reference source not found.**.

4.2 Local Coordinate System

4.2.1 Test Vehicle

The local coordinate system (x,y,z) for the Test Vehicle shall be defined such that the x-axis points toward the front of the vehicle, the y-axis towards the left (nearside) and the z-axis upwards, as shown in **Error! Reference source not found.**. The rotation of the Test Vehicle about the x-axis shall be defined as roll, the y-axis as pitch and the z-axis as yaw. The origin of the coordinate system shall lie on the ground plane, on the longitudinal centreline of the Test Vehicle and at its foremost point.

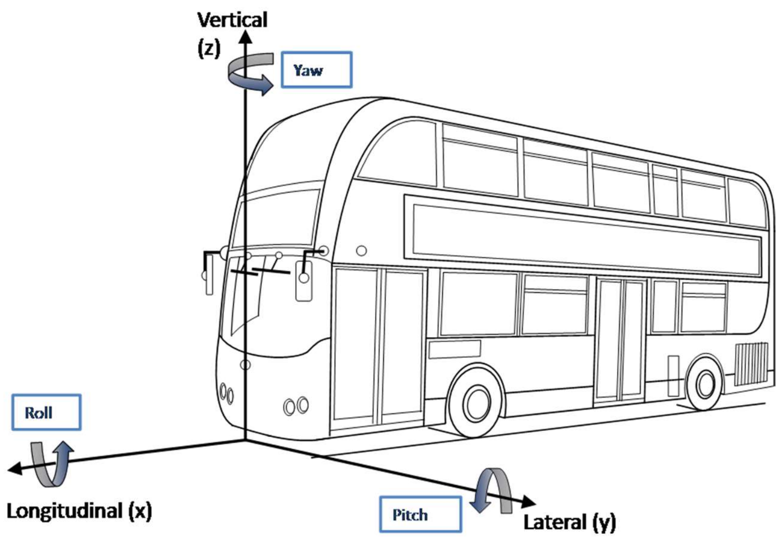

Figure 3: Local coordinate system and notation for test vehicle

4.3 Test Targets

4.3.1 The local coordinate systems (x,y,z) for the EPTa and EPTc test targets shall both be defined such that the x-axis points in the direction of walking, the y-axis towards the left and the z-axis upwards. The origin of the coordinate system shall lie on the ground plane, at the intersection of the test target centreline and a line perpendicular to the centreline passing through the test target hip point, as shown in Figure 4.

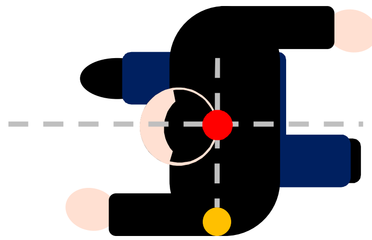

Figure 4: Origin of local coordinate systems for EPTa and EPTc test targets, illustrating test target hip point (orange), centrelines (grey) and local coordinate system origin (red)

4.3.2 The local coordinate systems (x,y,z) for the EBT test target shall be defined such that the x-axis points in the direction of travel, the y-axis towards the left and the z-axis upwards. The origin of the coordinate system shall lie on the ground plane, at the centre of the bottom bracket of the test target bicycle, as shown in Figure 5.

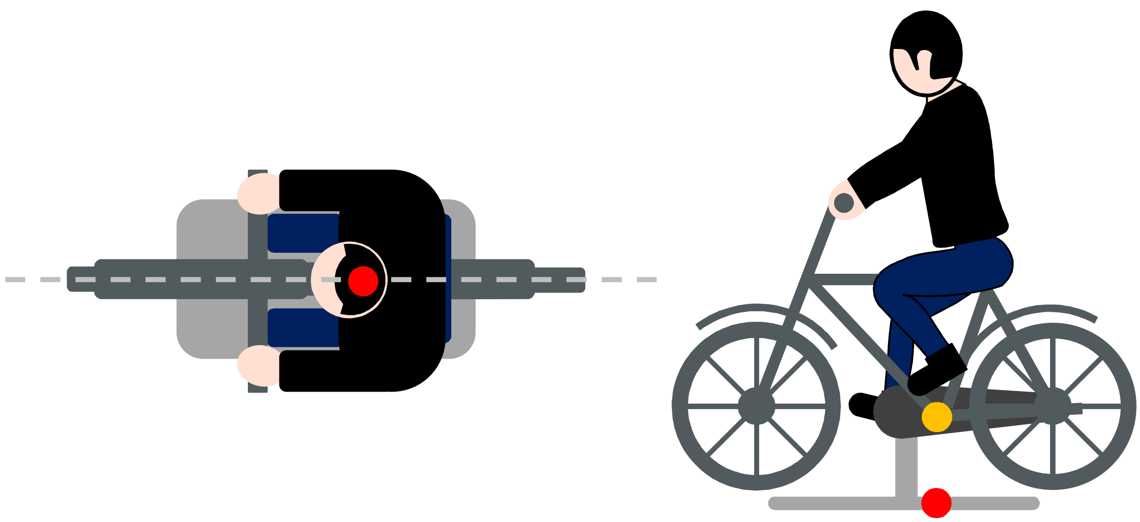

Figure 5: Origin of local coordinate systems for EBT test target, illustrating test target centreline (grey), centre of the bottom bracket (orange) and local coordinate system origin (red)

5 Measurements and variables

5.1 Variables to be measured

5.1.1 The variables which shall be measured continuously throughout testing can be seen in Table 1, along with the minimum operating ranges and measurement accuracy required.

Table 1: Variables to be measured continuously during testing with minimum operating ranges and maximum overall permitted measurement errors

Variable	Operating range (at least)	Measurement accuracy
Position (global coordinates) of test vehicle (TV_X, TV_Y)	200m in X-axis 100m in Y-axis	±0.03m
Position (global coordinates) of VRU test target (VRU_X, VRU_Y)	200m in X-axis 100m in Y-axis	±0.05m
Speed of test vehicle (V_{TV})	0 km/h to 30 km/h	0.1 km/h
Speed of VRU test target (V_{VRU})	0 km/h to 20 km/h	0.1 km/h
Heading (yaw) angle (θ) relative to global X-axis (θ_{TV}, θ_{VRU})	0˚ to 360˚	0.1˚
Test vehicle longitudinal acceleration (A_{TV})	± 15 m/s^2	0.1 m/s^2

5.1.2 Additional variables which shall be measured on a periodic basis, both before each test and at least every 30 minutes during testing, can be seen in Table 2, along with minimum operating ranges and maximum overall permitted measurement errors.

Table 2: Variables to be measured periodically during testing with minimum operating ranges and maximum overall permitted measurement errors

Variable	Operating range (at least)	Measurement accuracy
Ambient Temperature	-5˚C to +50˚C	±1˚C
Wind Speed	0 m/s to 20 m/s	± 0.2m/s
Ambient Illumination	0 lux to 150,000 Lux	±10%

5.2 Measuring equipment

5.2.1 Details of the sensors used to measure the required variables shall be recorded in the test report together with the position in which they are installed within the vehicle (measured relative to the local co-ordinate system for the test vehicle).

5.2.2 The default equipment to be used shall be a high-quality inertial navigation system in combination with differential GPS with data recorded at a sample rate of 100 Hz, which has been found to provide all continuously measured variables with sufficient accuracy. With such equipment, post-sampling digital filtering shall be as follows:

a) Position and speed need no additional digital filtering after data capture;

b) Acceleration and yaw rate shall be filtered with a phaseless digital filter complying with the requirements of ISO 15037-2:2002.

5.2.3 Alternatively, any measuring equipment that can be demonstrated to be compliant with the requirements of ISO 15037-2:2002 is permitted.

6 Test Conditions

6.1 Test Track

6.1.1 Tests shall be undertaken on a uniform, solid-paved surface with a consistent slope in any direction of between 0% and 1%. The surface must be paved and may not contain any irregularities (e.g. large dips or cracks, manhole covers or reflective studs) that may give rise to abnormal sensor measurements within a lateral distance of 3.0m to either side of the test path and within a longitudinal distance of 30m ahead of the Test Vehicle when the test ends.

6.2 Surroundings

6.2.1 Conduct testing such that only the Standardised Environmental Clutter specified in the particular test procedure is present within a lateral distance of 6.0m on the left side and 4.0m on the right side of the test vehicle path, and within a longitudinal distance of 30m ahead of the Test Vehicle when the test ends (Figure 6). No other vehicles, highway furniture, obstructions, other objects or persons protruding above the test surface that may give rise to abnormal sensor measurements are permitted in this area. Lane markings are permitted but not required.

6.2.2 The Test Vehicle must not pass under overhead signs, bridges, gantries or other significant structures during the test.

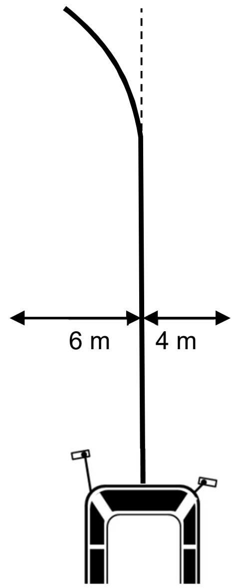

Figure 6: Area around the Test Vehicle path that must be free from all but clutter defined in the test procedure

6.2.3 The general view ahead and to either side of the test area shall comprise of a wholly plain manmade or natural environment (e.g. further test surface, plain coloured fencing or hoardings, natural vegetation or sky etc.) and must not comprise any highly reflective surfaces or contain any vehicle-like silhouettes that may give rise to abnormal sensor measurements.

6.3 Weather Conditions

6.3.1 Tests shall be undertaken only in compliance with the following weather conditions:

a) Ambient temperatures shall be between 0°C and 45°C
b) No precipitation shall be falling during testing. The surface is permitted to be damp during testing but the quantity of water present on the surface must be less than the amount liable to cause splash or spray during the test.
c) Horizontal visibility at ground level shall be greater than 1km.
d) Wind speeds shall be below 6m/s.
e) Natural ambient illumination must be homogenous in the test area and in excess of 2000 lux with no strong shadows cast across the test area other than those caused by the Test Vehicle, VRU or standardised environmental clutter. Tests shall not be undertaken in such conditions that visual sensors are adversely affected by direct sunlight. However, if it is found that such conditions exist, it shall be recorded in the test report.

6.4 Test Targets

6.4.1 Pedestrian test targets shall be the EPTa and EPTc and the cyclist test target shall be the EBT. The relevant VRU test targets shall be moved around the test area and delivered to the point of impact with the test vehicle by a low-profile platform.

6.4.2 The system will be capable of moving the vulnerable road user at speeds of up to at least 20 km/h, to accelerate at 3 m/s^2 or more, and maintaining constant speed within a tolerance of 0.5 km/h. Lateral deviation from an intended straight path shall be no more than 0.05m.

6.4.3 The platform may be self-propelled or moved by a pulley system. However, in either case any visible parts of the combined platform and VRU mounting system shall be of a uniform colour that blends well with the test track beneath it. The default colour is grey.

6.4.4 The platform and VRU mounting system shall not influence RADAR return and RADAR absorbing material may be used at the VRU mounting points to ensure compliance with this requirement.

6.4.5 The distance between the lower edge of the VRU and the road surface shall be less than 25 mm.

7 Vehicle preparation

7.1 Aftermarket systems

7.1.1 For aftermarket systems, the system shall be installed on a standard test vehicle of category M_3[2] with the following characteristics:

a) Overall Length: 9.5 to 11 metres

b) Number of axles: 2

c) Axle configuration: 1 front (steered), 1 rear

7.1.2 Where considering the approval of aftermarket systems on vehicles that are different to this specification in terms of length, number of axles or steering configuration, then retesting with the relevant test vehicle shall be required to guarantee satisfactory performance.

7.2 OEM systems

7.2.1 For an OEM system, the rating shall apply to the vehicle as a whole and any other models that share the same critical properties. Thus, the test vehicle will be whatever vehicle is supplied by the manufacturer for test, with this recorded in the Test Report.

7.3 Dealer fit systems

7.3.1 Dealer fit systems may be tested either as integrated systems for the vehicle or as aftermarket systems fitted to a standard test vehicle. The choice shall be recorded in the Test Report.

[2] As defined by European Type Approval Framework Directive 2007/46/EC

7.4 Blind Spot Safety System

7.4.1 **Installation**

7.4.2 The blind spot safety system to be tested shall be installed on the test vehicle in accordance with the manufacturer's instructions.

7.4.3 Each blind spot safety system may enable more than one blind spot safety function. Suppliers may market such systems with a variety of optional configurations, including additional functions outside of the scope of this document. The exact configuration of the system tested must be recorded in the Test Report.

7.4.4 It is permitted to install multiple blind spot safety systems on the vehicle. This may arise where multiple separate systems, for example from different suppliers, are installed on the same test vehicle for reasons of increased efficiency. In this case, it must be ensured that no conflict, that has the potential to affect results, occurs between systems in terms of the location and field of view of the sensors, the potential for one sensor to interfere with another or the location of the user interface within the vehicle.

7.5 Settings

7.5.1 Some systems may incorporate driver configurable settings. Where those settings can influence performance, for example the sensitivity of proximity information signal or collision warnings, they shall be set to the middle setting (midpoint), or where this is not possible to the next latest possible setting. Examples are illustrated in Table 3, where a setting that would tend to make an information signal or warning later is one that would reduce the range or sensitivity of the application, whilst earlier would tend to make the application more sensitive or to detect at longer range.

Table 3: Blind spot safety system setting for testing

<table>
<tr><td rowspan="3">Early</td><td colspan="2">Setting 1</td><td colspan="2">Setting 2</td><td rowspan="3">Late</td></tr>
<tr><td>Setting 1</td><td colspan="2">Setting 2</td><td>Setting 3</td></tr>
<tr><td>Setting 1</td><td>Setting 2</td><td>Setting 3</td><td>Setting 4</td></tr>
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7.5.2 In this way, a system with only two settings gets adjusted to the least sensitive setting, or latest intervention, a system with 3 possible settings gets adjusted to the midpoint and a system with four settings gets adjusted to the next latest setting from the midpoint.

7.6 Tyres

7.6.1 Perform the testing with road legal tyres of the size, speed and load rating specified by the vehicle manufacturer. Inflate tyres to the pressures recommended by the manufacturer for the least laden normal condition (unladen or lightly laden). Tyre pressures immediately before the test shall be recorded in the Test Report.

7.7 Test Vehicle Mass

7.7.1 The load space on the vehicle shall be empty (unladen condition) except for the driver, test equipment and optionally one test engineer. The fuel tank shall be filled to no less than 90% of the capacity specified by the manufacturer, whilst other fluid levels, such as lubricants etc., are set according to manufacturer recommendations. The mass of the vehicle and its distribution across the axles shall be recorded in the conditions tested.

7.7.2 All test equipment installed in the vehicle should be securely attached to it such that it cannot move under maximum braking forces.

8 Test scenarios

8.1 This section describes the methods for testing the performance of blind spot system functions. The overall approach taken is to consider tests relating to two different key collision scenarios: where a bus moves off from rest and where a bus makes a left (nearside) turn. Within each collision scenario, more than one specific test method is required to fully define blind spot system performance in that collision scenario. The method of evaluating the specific results of each individual test and assessment are therefore presented across this section.

8.2 Moving-Off Scenarios

8.2.1 General Test Scenario Configuration

8.2.1.1 The general test scenario configuration is designed to be representative of collisions where a pedestrian walks in front of a stationary bus in an urban area. The driver moves the bus off from rest, without seeing the VRU in front of the vehicle, resulting in a collision. Representative test vehicle and VRU test target starting positions and intended motions are illustrated in Figure 7, alongside positioning information for the standardised environmental clutter.

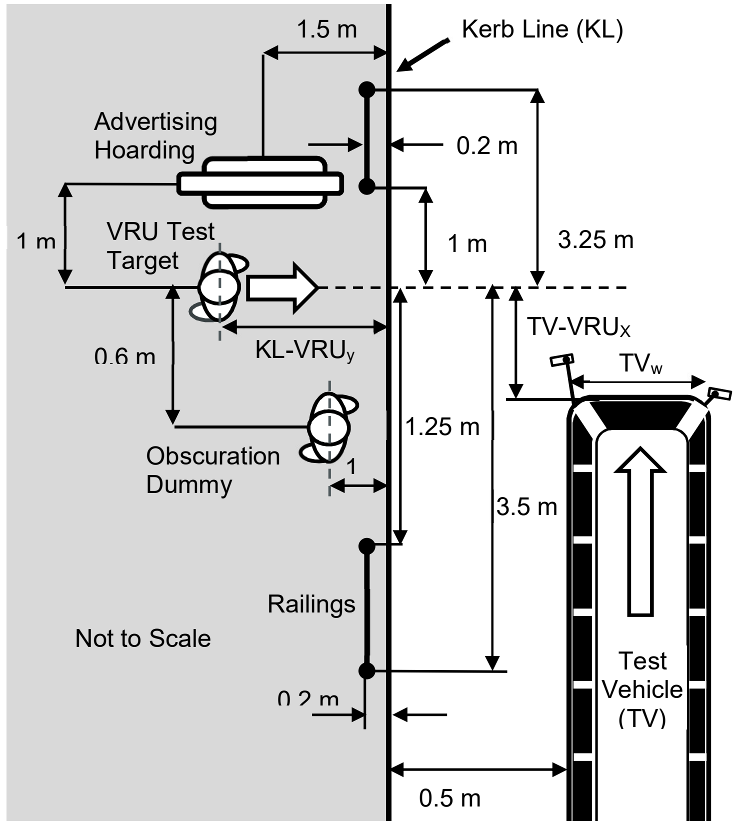

Figure 7: General test configuration for test vehicle (TV), VRU test target (VRU) and standardised environmental clutter positions at time T0 with intended motions for moving-off test scenarios

8.2.2 All test scenario configuration dimensions illustrated in Figure 7 are described in greater detail below. Fixed dimensions are enumerated, whilst dimensions that vary with each test scenario are described by their acronym:

a) Test vehicle width (TV_W)

b) Kerb Line (KL) is a line parallel to the global X-axis defining the nominal kerb edge of the road

c) Lateral distance from nearside edge of TV to KL = 0.5m

d) Lateral distance from KL to centreline of VRU ($KL\text{-}VRU_Y$)

e) Longitudinal distance from front of Test Vehicle to centreline of VRU ($TV\text{-}VRU_X$)

f) Lateral distance from KL to Obscuration Dummy centreline = 1m

g) Longitudinal distance from centreline of VRU to centreline of Obscuration Dummy = 0.6m

h) Lateral distance from KL to centreline of railings = 0.2m

i) Longitudinal distance from VRU centreline to leading edge of foremost railing = 3.25m

j) Longitudinal distance from VRU centreline to trailing edge of foremost railing = 1m

k) Longitudinal distance from VRU centreline to leading edge of rearmost railing = 1.25m

l) Longitudinal distance from VRU centreline to trailing edge of rearmost railing = 2.5m

m) Lateral distance from Kerb Line to centreline of Advertising hoarding = 1.5m

n) Longitudinal distance from VRU centreline to centreline of Advertising Hoarding = 1m

8.3 Moving-Off Proximity Information signal (MOPI) Scenario

8.3.1 This test assesses the ability of a system to detect a pedestrian manoeuvring around the front end of a stationary bus and provide an effective VRU proximity information signal. The test vehicle, test targets and standardised environmental clutter shall be set up as specified in Section 8.2.1 with additional test scenario specific parameters as detailed in Table 4.

Table 4: Definition of test scenario specific parameters for the Moving-Off Proximity Information signal (MOPI) scenario

Parameter	Test Scenario		
	Adult Near (True Positive)	Child Mid (True Positive)	Adult Far (True Positive)
TV-VRU_Y	1.7 m	1.7 m	1.7 m
TV-VRU_X[3]	0.3 m	[2.5] m	[4.0] m
VRU Test Target	EPTa	EPTc	EPTa
VRU Speed (V_{VRUy})	3 km/h ± 0.2 km/h	5 km/h ± 0.2 km/h	5 km/h ± 0.2 km/h

8.3.2 For all test scenarios, a constant acceleration of 1 m/s^2 ± 0.2 m/s^2 (A_{VRUy}) shall be applied to the VRU test target in the direction of the negative Y-axis until the steady state VRU speed (V_{VRUy}) is met, at which A_{VRUy} shall drop to a nominal acceleration of 0 m/s^2 where the steady state speed shall be maintained constant until the VRU has completely passed the front of the test vehicle. The test vehicle ignition shall be switched to the fully on position with test vehicle speeds in both the x-axis and y-axis (V_{TVx}, V_{TVy}) maintained at 0 km/h through all test scenarios. The motion of the test vehicle and VRU are enumerated below:

a) A_{VRUy} = 1 m/s^2 ± 0.2 m/s^2 until V_{VRUy} is reached, thereafter nominally 0 m/s^2.

b) $V_{TVx} = V_{TVy} = 0$ km/h.

8.3.3 The start of each test (T_0) shall be taken as the point where the acceleration (A_{VRUy}) is first applied to the VRU test target. The completion of each test (T_1) shall be taken as the point at which no part of the VRU test target remains in the path of the test vehicle, defined as if the test vehicle moved purely in the x-axis.

8.3.4 The status of the blind spot information and warning signals shall be recorded, along with VRU test target position, from time T_0–1 second to T_1. The evaluation distance shall be taken as the difference between the VRU test target positions at T_0 and T_1.

8.3.5 Each specified test scenario shall be undertaken once.

[3] Note that to achieve variation in the longitudinal separation between test vehicle and moving VRU dummy, the path of the VRU shall remain fixed and the start point of the test vehicle shall be moved backward, away from the VRU path, as required.

8.5 Moving-Off collision Warning and motion Inhibit (MOWI) Scenario

8.5.1 This test assesses the ability of a system to detect a pedestrian located in the path of a bus moving off from rest and either intervene to inhibit the motion of the bus or to provide an effective VRU collision warning signal. The test vehicle, test targets and standardised environmental clutter shall be set up as specified in Section 8.2.1 with additional test scenario specific parameters as detailed in Table 5.

8.5.2 VRU test targets shall be positioned laterally anywhere between 25% and 75% of the width of the test vehicle (i.e. $0.25*TV_W-0.75*TV_W$), with the exact position determined by the Test Service on a worst-case basis.

Table 5: Definition of test scenario specific parameters for the Moving-Off collision Warning and motion Inhibit (MOWI) scenario

Parameter	Test Scenario		
	EPTa Near (Motion Inhibit)	EPTc Near (Motion Inhibit)	EPTa Far (Motion Inhibit or Collision Warning)
$TV\text{-}VRU_Y$	$0.25*TV_W-0.75*TV_W$	$0.25*TV_W-0.75*TV_W$	$0.25*TV_W-0.75*TV_W$
$TV\text{-}VRU_X$[4]	0.3 m	0.3 m	[4.0] m
VRU Test Target	EPTa	EPTc	EPTc

8.5.3 VRU test target speeds in the x-axis and y-axis (V_{VRUx}, V_{VRUy}) shall be maintained at 0 km/h throughout all test scenarios.

8.5.4 The test vehicle shall be driven such that it pulls away from rest in the x-axis and towards the VRU test target, before braking to a stop, using the following procedure:

a) Select an appropriate forward gear

b) Release park brake

c) Depress accelerator

d) Accelerate to no more than 10 km/h

e) Once TTC reduces to ≤0.75 seconds, decelerate to 0 km/h

8.5.5 The start of each test (T_0) shall be taken as the point where the acceleration is first applied to the test vehicle. The completion of each test (T_1) shall be taken as either the point at which the test vehicle motion inhibit function is activated, the point at which the test vehicle is automatically brought to a halt without driver intervention or the first point at which the TTC becomes 0.75 seconds.

8.5.6 The status of the blind spot information and warning signals and the motion inhibit system shall be recorded, along with the VRU test target and

[4] Note that to achieve variation in the longitudinal separation between test vehicle and moving VRU dummy, the path of the VRU shall remain fixed and the start point of the test vehicle shall be moved backward, away from the VRU path, as required.

test vehicle positions, from time T_0 to T_1 + 3 seconds. The evaluation distance shall be taken as the difference between the VRU test target positions at T_0 and T_1.

8.5.7 Each specified test scenario shall be undertaken once.

8.5.8 Should the motion inhibit function be activated, it shall be deactivated at time no earlier than T_1+ 3 seconds and no later than T_1 + 10 seconds through the motion inhibit over-ride function.

8.5.9 The motion inhibit over-ride function shall be applied manually through one of the following conditions:

a) A throttle action that requires deliberate additional force similar to kick-down actions or other defined sequence of inputs untypical of normal driving

b) A button that is held down for at least 3 seconds

c) A switch, series of switches or menu-based screen interface, where at least 3 discrete actions are required

8.5.10 A collision warning signal shall be issued whilst the motion inhibit over-ride function is applied.

8.5.11 With the motion inhibit over-ride function applied, the test vehicle shall be driven away from the test target to a finish point no further than 10 m away where no further hazards are present.

8.5.12 The motion inhibit over-ride function shall deactivate before reaching the finish point described in 8.5.11.

8.7 Nearside Turn Scenarios

8.7.1 General Test Scenario Configuration

8.7.2 The general test scenario configuration is designed to be representative of collisions with VRUs during nearside turn manoeuvres in an urban area. Two categories of test scenario are assessed: the first where a bicyclist cycles alongside the nearside of a bus about to perform a nearside turn manoeuvre and the second where a pedestrian crosses the entrance of a road on the nearside of a bus about to perform a nearside turn manoeuvre into the road. Representative test vehicle and VRU test target starting positions and intended motions are illustrated in Figure 8, alongside positioning information for the standardised environmental clutter.

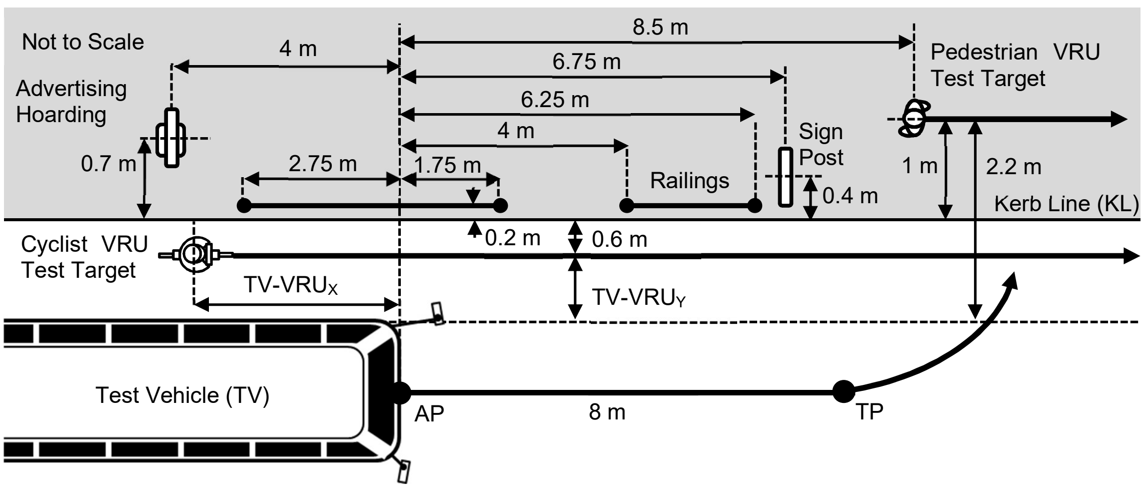

Figure 8: General test configuration for test vehicle (TV), VRU test target (VRU) and standardised environmental clutter positions at time T0 with intended motions for nearside turn test scenarios

8.7.3 All test scenario configuration dimensions illustrated in Figure 8 are described in greater detail below. Fixed dimensions are enumerated, whilst dimensions that vary with each test scenario are described by their acronym:

a) Test vehicle length (TV_L)

b) Kerb Line (KL) is a line parallel to the global X-axis defining the nominal kerb edge of the road, prior to the simulated junction.

c) Acceleration Point (AP) is the X-position of the foremost point of the test vehicle at the moment the test vehicle begins to accelerate

d) Turn Point (TP) is the X-position of the foremost point of the test vehicle at the moment that the test vehicle commences steering

e) Longitudinal distance from AP to centreline of cyclist VRU ($TV\text{-}VRU_X$)

f) Lateral distance from nearside of Test Vehicle to centreline of cyclist VRU ($TV\text{-}VRU_Y$)

g) Lateral distance from KL to centreline of cyclist VRU = 0.6 m

h) Longitudinal distance from AP to centreline of pedestrian VRU = 8.5 m

i) Lateral distance from nearside of Test Vehicle to centreline of cyclist VRU = 2.0 m

j) Lateral distance from KL to centreline of cyclist VRU = 1.0 m

k) Longitudinal distance from AP to TP = 8.0 m

l) Lateral distance from KL to centreline of railings = 0.2 m

m) Longitudinal distance from AP to leading edge of foremost railing = 6.25 m

n) Longitudinal distance from AP to trailing edge of foremost railing = 4.0 m

o) Longitudinal distance from AP to leading edge of rearmost railing = 1.75 m

p) Longitudinal distance from AP to trailing edge of rearmost railing = 2.75 m

q) Lateral distance from KL to centreline of Advertising Hoarding = 0.7m

r) Longitudinal distance from AP to centreline of Advertising Hoarding = 4.0 m

s) Lateral distance from KL to centreline of signpost = 0.4 m

t) Longitudinal distance from AP to centreline of signpost = 6.75 m

8.9 Nearside Turn Proximity Information signal (NTPI) Scenario

8.9.1 This test assesses the ability of a system to detect a cyclist manoeuvring along the nearside of a stationary bus and provide an effective VRU proximity information signal. The test vehicle, test target and standardised environmental clutter shall be set up as specified in Section 8.7.1 with additional test scenario specific parameters detailed in Figure 9 and Table 6.

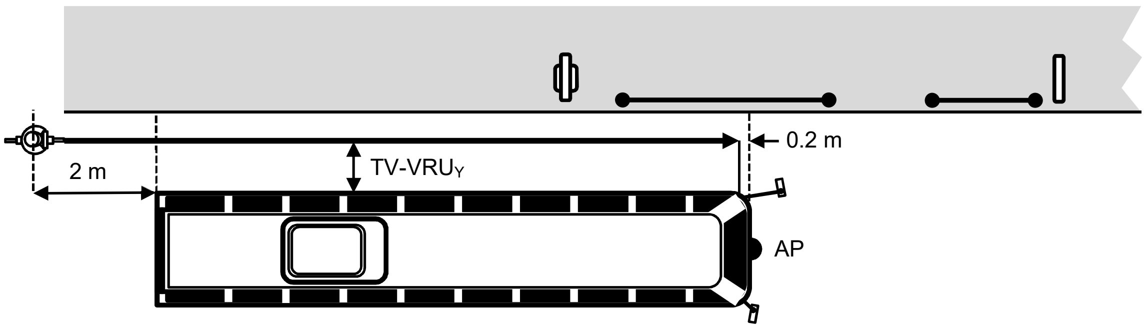

Figure 9: Test target positions at time T_0 and T_1 for Nearside Turn Proximity Information signal (NTPI) scenario whilst test vehicle is stationary

Table 6: Definition of test scenario specific parameters for the Nearside Turn Proximity Information signal (NTPI) scenario

Parameter	Test Scenario	
	Cyclist Near (True Positive)	Cyclist Far (True Positive)
TV_X	AP	AP
$TV\text{-}VRU_Y$	0.6 m	[1.5] m
$TV\text{-}VRU_X$	TV_L + 2 m	TV_L + 2 m
VRU Test Target	EBT	EBT

8.9.2 For all test scenarios, the VRU test target shall be accelerated in the direction of the positive X-axis to a steady state speed of 10 km/h ± 0.2 km/h within a distance of 2 m. The VRU test target speed shall be maintained as constant until decelerated to rest at a rate of 2 m/s^2 ± 0.5 m/s^2 such that the test target comes to rest at a position 0.2 m rearward of the AP (in the negative X-axis). The test vehicle ignition shall be switched to the fully on position with test vehicle speeds in both the x-axis and y-axis (V_{TVx}, V_{TVy}) maintained at 0 km/h throughout all test scenarios.

8.9.3 The start of each test (T_0) shall be taken as the point where the acceleration is first applied to the VRU test target. The completion of each test (T_1) shall be taken as the point at which the VRU test target comes to rest.

8.9.4 The status of the blind spot information and warning signals shall be recorded, along with VRU test target position, from time T_0–1 second to T_1. The evaluation distance shall be taken as between $VRU_X = TV_L$ – 1 m and the VRU test target position at T_1.

8.9.5 Each specified test scenario shall be undertaken once.

8.10 Nearside Turn Low relative Cyclist speed (NTLC) Scenario

8.10.1 This test assesses the ability of a system to detect a cyclist manoeuvring at a low relative speed along the nearside of a bus performing a nearside turn and provide effective VRU proximity information and collision warning signals. The test vehicle, test target and standardised environmental clutter shall be set up as specified in Section 8.7.1 with additional test scenario specific parameters as detailed in Figure 10 and Table 7.

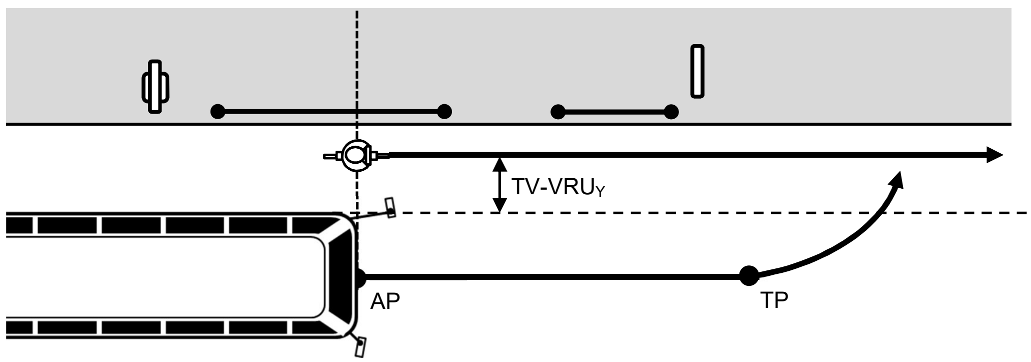

Figure 10: Test vehicle and test target position at time T_0 for Nearside Turn Low relative Cyclist speed (NTLC) scenario

Table 7: Definition of test scenario specific parameters for the Nearside Turn Low relative Cyclist speed (NTLC) scenario

Parameter	Test Scenario	
	Cyclist Near (True Positive)	Cyclist Far (True Positive)
TV_X at T_0	AP	AP
$TV\text{-}VRU_Y$ at T_0	0.6 m	[1.5] m
$TV\text{-}VRU_X$ at T_0	0 m	0 m
VRU Test Target	EBT	EBT
TV Angle of Turn (α) at T_2	27°	35°
VRU_X at T_2	AP + 10 m	AP + 11.25 m

8.10.2 For all test scenarios, the test vehicle shall be accelerated in the X-axis direction to a steady state speed of 10 km/h ± 1 km/h within a distance of 8 m. The test vehicle speed shall be maintained as constant until the completion of the test (T_1). At the turn point (TP), steering shall be applied to the test vehicle such that the foremost point of the test vehicle centreline follows the arc of a circle with a radius (R) of 10 m.

8.10.3 The VRU test target shall commence acceleration at the moment in time when the test vehicle X-axis position is 0.2m greater than that of the AP. The VRU test target shall be accelerated in the direction of the positive X-axis to a nominal steady state speed of 6.5 km/h within a distance of 2 m.

8.10.4 The moment in time at which the VRU test target path would conflict with the test vehicle path (T_2) shall be defined as the impact point. On reaching the impact point, the test vehicle shall have travelled the length of a 10 m radius arc with an angle of turn of α (where α is defined as the central angle of a circle measured in degrees, see Figure 11), whilst the VRU test target shall have reached a position VRU_X.

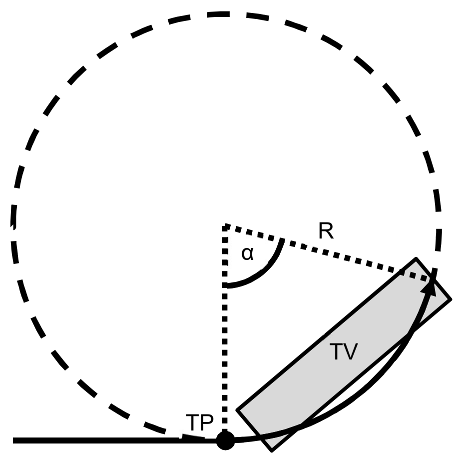

Figure 11: Illustration of central angle (α) of arc of a circle of radius (R) relating to the steering applied to the test vehicle (TV) from the turn point (TP)

8.10.5 The speed of the VRU test target may be varied in response to the actual speed and path achieved by the test vehicle to ensure compliance with the above impact point criteria. This moment approximates the moment of impact, but it should be noted that the exact point of impact on the vehicle and the exact time of impact will vary slightly depending on the steering geometry of the test vehicle.

8.10.6 The start of each test (T_0) shall be taken as the point where the acceleration is first applied to the test vehicle. The completion of each test (T_1) shall be taken as the moment in time 1 second before the impact point (i.e. T_1=T_2–1 second).

8.10.7 To avoid unnecessary damage to the VRU test target, the test vehicle and test target shall both be decelerated to a halt between T_1 and T_2.

8.10.8 The status of the blind spot information and warning signals shall be recorded, along with the VRU test target and test vehicle positions, from time T_0 to T_1 + 3 seconds. The proximity test evaluation distance shall be taken as the difference between the VRU test target positions at T_0 and TP, whilst the collision test evaluation distance shall be taken as the difference between positions at TP and T_1.

8.10.9 Each specified test scenario shall be undertaken once.

8.12 Nearside Turn High relative Cyclist speed (NTHC) Scenario

8.12.1 This test assesses the ability of a system to detect a cyclist manoeuvring at a high relative speed along the nearside of a bus performing a nearside turn and provide effective VRU proximity information and collision warning signals. The test vehicle, test target and standardised environmental clutter shall be set up as specified in Section 8.7.1 with additional test scenario specific parameters as detailed in Figure 12 and Table 8.

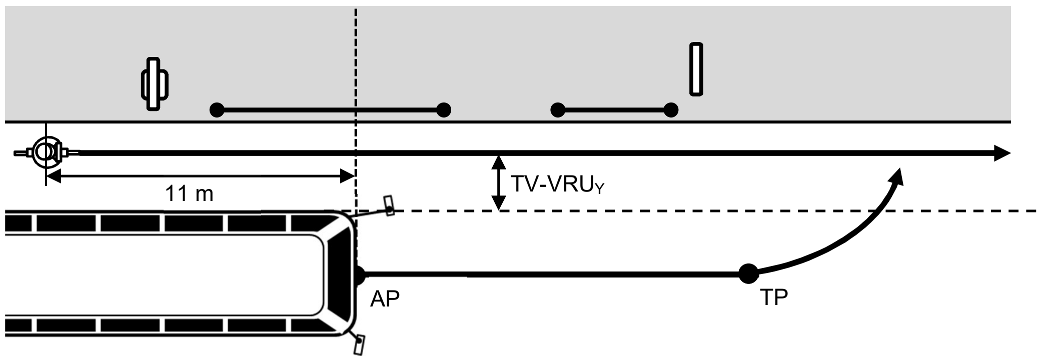

Figure 12: Test vehicle and test target position at time T_0 for Nearside Turn High relative Cyclist speed (NTHC) scenario

8.12.2 For all test scenarios, the test vehicle shall be accelerated from its start position to a steady state speed of 4 km/h and maintained as constant until the acceleration point (AP). At the AP, the test vehicle shall be accelerated in the X-axis direction to a steady state speed of 14 km/h ± 1 km/h within a distance of 8 m. The test vehicle speed shall be maintained as constant until the completion of the test (T_1). At the turn point (TP), steering shall be applied to the test vehicle such that the foremost point of the test vehicle centreline follows the arc of a circle with a radius (R) of 10 m.

8.12.3 Prior to the test vehicle reaching the AP, the VRU test target shall be accelerated from its start position to a nominal steady state speed of 18 km/h. As the test vehicle reaches the AP, the VRU shall be a distance of 11 m ± 0.5 m rearward of the AP in the negative X-axis.

8.12.4 Start positions and initial accelerations for the test vehicle and VRU test target shall be at the discretion of the Test Service to ensure compliance with these positioning requirements.

Table 8: Definition of test scenario specific parameters for the Nearside Turn High relative Cyclist speed (NTHC) scenario

Parameter	Test Scenario	
	Cyclist Near (True Positive)	Cyclist Far (True Positive)
TV_X at T_0	AP	AP m
TV-VRU_Y at T_0	0.6 m	[1.5] m
TV-VRU_X at T_0	AP – 11 m	AP – 11 m
VRU Test Target	EBT	EBT
TV Angle of Turn (α) at T_2	27°	35°
VRU_X at T_2	AP + 10 m	AP + 11.25 m

8.12.5 The moment in time at which the VRU test target path would conflict with the test vehicle path (T_2) shall be defined as the impact point. On reaching the impact point, the test vehicle shall have travelled the length of a 10 m radius arc with an angle of turn of α (Figure 11), whilst the VRU test target shall have reached a position VRU_X.

8.12.6 The speed of the VRU test target may be varied in response to the actual speed and path achieved by the test vehicle to ensure compliance with the above impact point criteria. This moment approximates the moment of impact, but it should be noted that the exact point of impact on the vehicle and the exact time of impact will vary slightly depending on the steering geometry of the test vehicle.

8.12.7 The start of each test (T_0) shall be taken as the point where the acceleration is first applied to the test vehicle. The completion of each test (T_1) shall be taken as the moment in time 1 second before the impact point (i.e. $T_1=T_2–1$ second).

8.12.8 To avoid unnecessary damage to the VRU test target, the test vehicle and test target shall both be decelerated to a halt between T_1 and T_2.

8.12.9 The status of the blind spot information and warning signals shall be recorded, along with the VRU test target and test vehicle positions, from time T_0 to T_1 + 3 seconds. The proximity test evaluation distance shall be taken as the difference between the VRU test target positions at T_0 and TP, whilst the collision test evaluation distance shall be taken as the difference between positions at TP and T_1.

8.12.10 Each specified test scenario shall be undertaken once.

8.14 Nearside Turn Crossing Pedestrian (NTCP) Scenario

8.14.1 This test assesses the ability of a system to detect a pedestrian crossing an entrance to a road whilst the bus performs a nearside turn into the road and provide effective VRU proximity information and collision warning signals. The test vehicle, test target and standardised environmental clutter shall be set up as specified in Section 8.7.1 with additional test scenario specific parameters as detailed in Figure 13.

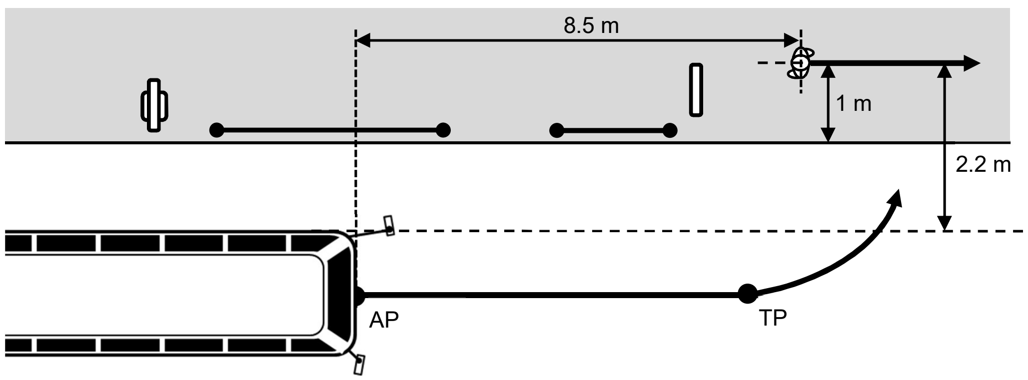

Figure 13: Test vehicle and test target position at time T_0 for Nearside Turn Crossing Pedestrian (NTCP) scenario

8.14.2 The test vehicle shall be accelerated in the X-axis direction to a steady state speed of 10 km/h ± 1 km/h within a distance of 8 m. Test vehicle speed shall be maintained as constant until the completion of the test (T_1). At the turn point (TP), steering shall be applied to the test vehicle such that the foremost point of the test vehicle centreline follows the arc of a circle with a radius (R) of 10 m.

8.14.3 The VRU test target shall be accelerated in the direction of the positive X-axis to a nominal steady state speed of 5 km/h within a distance of 2 m. The VRU test target shall commence acceleration at the moment in time such that, when the test vehicle has travelled the length of a 10 m radius arc with an angle of turn of 35° (Figure 11), the VRU test target shall have reached a position VRU_X = AP + 12.1 m. The moment in time that this point occurs shall be defined as the impact point (T_2).

8.14.4 The speed of the VRU test target may be varied in response to the actual speed and path achieved by the test vehicle to ensure compliance with the above impact point criteria. This moment approximates the moment of impact, but it should be noted that the exact point of impact on the vehicle and the exact time of impact will vary slightly depending on the steering geometry of the test vehicle.

8.14.5 The start of each test (T_0) shall be taken as the point where the acceleration is first applied to the test vehicle. The completion of each test (T_1) shall be taken as the moment in time 1 second before the impact point (i.e. T_1=T_2–1 second).

8.14.6 To avoid unnecessary damage to the VRU test target, the test vehicle and test target shall both be decelerated to a halt between T_1 and T_2.

8.14.7 The status of the blind spot information and warning signals shall be recorded, along with the VRU test target and test vehicle positions, from time T_0 to T_1 + 3 seconds. The proximity test evaluation distance shall be taken as the difference between the VRU test target positions at T_0 and TP, whilst the collision test evaluation distance shall be taken as the difference between positions at TP and T_1.

8.14.8 This test scenario shall be undertaken once.

8.16 Nearside Turn No test Target (NTNT) Scenario

8.16.1 This test assesses the false positive rate of a system in high levels of environmental clutter for both the VRU proximity information and collision warning signals. This may be used to evaluate the effectiveness of the system in differentiating between the at-risk VRUs and the environment. The test vehicle and standardised environmental clutter shall be set up as specified in Section 8.7.1, with additional test scenario specific parameters as detailed in Figure 14.

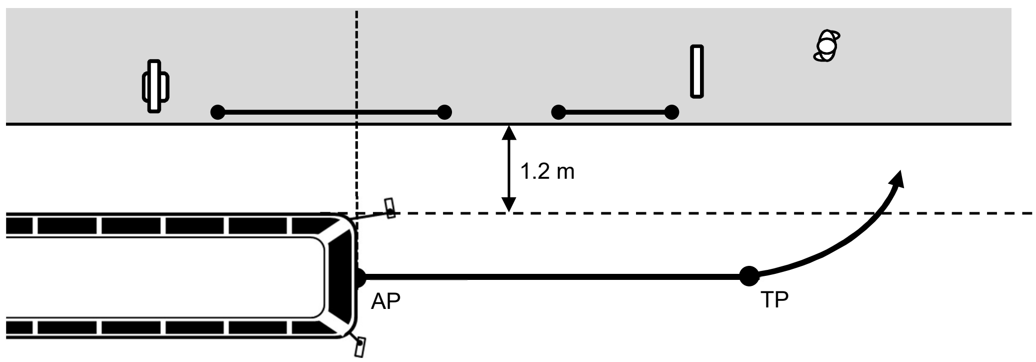

Figure 14: Test vehicle and test target position at time T_0 for Nearside Turn No test Target (NTNT) scenario

8.16.2 The test vehicle shall be accelerated in the X-axis direction to a steady state speed of 10 km/h ± 1 km/h within a distance of 8 m. Test vehicle speed shall be maintained as constant until the completion of the test (T_1). At the turn point (TP), steering shall be applied to the test vehicle such that the foremost point of the test vehicle centreline follows the arc of a circle with a radius (R) of 10 m.

8.16.3 The start of each test (T_0) shall be taken as the point where the acceleration is first applied to the test vehicle. The completion of each test (T_1) shall be taken as the moment in time that the test vehicle has traversed the arc of the circle for an angle of turn (α) of 75°.

8.16.4 The status of the blind spot information and warning signals shall be recorded, along with the VRU test target and test vehicle position, from time T_0-1 second to T_1. The evaluation distance shall be taken as the difference between the VRU test target positions at T_0 and T_1.

8.16.5 This test scenario shall be undertaken once.

9 Assessment of results

9.1 Moving-Off Proximity Information signal (MOPI) Scenario

9.1.1 Test Scenario Performance Evaluation

9.1.1.1 The evaluation of the blind spot system performance during the Moving-Off Proximity Information signal (MOPI) test scenarios shall be assessed according to Table 9.

Table 9: Evaluation of test performance for the Moving-Off Proximity Information signal (MOPI) test scenarios

Test Scenario	Points Available	Result Criteria	Result Metric	Score
All Scenarios (False Positive)	-2 to 0	Proximity information signal status before T_0 in any test condition	Inactive [0] Active [-2]	
Adult Near (True Positive)	0 to 1	Proportion of evaluation distance for which proximity information signal was active	100% Active [1] 100% Inactive [0]	
Child Mid (True Positive)	0 to 1		100% Active [1] 100% Inactive [0]	
Adult Far (False Positive)	-1 to 0		100% Inactive [0] 100% Active [-1]	
All Scenarios (False Positive)	-2 to 0	Collision warning status in any test scenario	Inactive [0] Active [-2]	
Max. Points	**2**		**Total Score**	
			Total Score/Max. Points	

9.1.2 **HMI Performance Evaluation**

9.1.3 The evaluation of the performance of the blind spot system HMI across all Moving-Off Proximity Information signal (MOPI) test scenarios shall be assessed according to Table 10.

Table 10: Evaluation of human-machine interface (HMI) performance for the Moving-Off Proximity Information signal (MOPI) test scenarios

HMI Criteria	Points Available	Result Criteria	Score
Proximity information signal transmitted over the visual mode only	0 to 3	Visual [3] Tonal or Haptic or Speech [0]	
Visual proximity information signal is located within a horizontal field of view angle of between ±30°, without causing an obstruction to direct or indirect vision	0 to 1	In zone [1] Out of zone [0]	
Visual proximity information signal is amber in colour	0 to 1	Amber [1] Other colour [0]	
Visual proximity information signal ceases automatically within [1] second of the VRU moving out of vehicle path	0 to 1	Ceases within [1] sec [1] Does not cease/ceases in ≥1s [0]	
Max. Points	**6**	**Total Score**	
		Total Score/Max. Points	

9.2 Moving-Off collision Warning and motion Inhibit (MOWI) Scenario

9.2.1 Test Scenario Performance Evaluation

9.2.1.1 The evaluation of the blind spot system performance during the Moving-Off collision Warning and motion Inhibit (MOWI) test scenarios shall be assessed in accordance with Table 11.

Table 11: Evaluation of test performance for the Moving-Off collision Warning and motion Inhibit (MOWI) test scenarios

Test Scenario	Points Available	Result Criteria	Result Metric	Score
Adult Near (Motion Inhibit)	0 to 1	The vehicle remains stationary despite the driver actions	Stationary [1] Motion [0]	
Child Near (Motion Inhibit)	0 to 1		Stationary [1] Motion [0]	
Child Far (Motion Inhibit or Collision Warning)	0 to 1	The vehicle remains stationary despite the driver actions, or is automatically brought to a halt without driver intervention before the point of collision	Stationary [1] Halted: No Driver Intervention [1] Halted: With Driver Intervention [0]	
	0 to 1	Proportion of evaluation distance for which collision warning was active	100% Active [1] 100% Inactive [0]	
Max. Points	**3**		**Total Score**	
			Total Score/Max. Points	

9.2.2 HMI Performance Evaluation

9.2.2.1 The evaluation of the performance of the blind spot system HMI across all Moving-Off collision Warning and motion Inhibit (MOWI) test scenarios shall be assessed in accordance with Table 12.

Table 12: Evaluation of human-machine interface (HMI) performance for the Moving-Off collision Warning and motion Inhibit (MOWI) test scenarios

HMI Criteria	Points Available	Result criteria	Score
Collision warning signal is transmitted over at least two modes	0 to 1	Multi-mode [1] Single mode [0]	
Collision warning signal is transmitted over at least one of audible/haptic modes	0 to 1	Includes Audible/Haptic Mode [1] No Audible/Haptic Modes [0]	
Collision warning signal uses a different mode to the proximity information signal or is distinctly different in presentation	0 to 1	Different [1] Similar [0]	
Visual collision warning signal is located within a horizontal field of view angle of between ±30°, without causing an obstruction to direct or indirect vision	0 to 1	In zone [1] Out of zone [0]	
Visual collision warning signal is red in colour	0 to 1	Red [1] Other colour [0]	
Visual collision warning signal displayed on windscreen via a head-up display that does not obstruct driver vision	0 to 1	HUD [1] No HUD [0]	
Audible collision warning signal does not use speech coding	0 to 1	Tonal [1] Speech Coding [0]	
Tonal collision warnings are distinct from other sounds used within the vehicle	0 to 1	Distinct [1] Similar [0]	
Tonal collision warnings have a signal to ambient noise ratio of greater than 1.3 between relevant loudness spectra	0 to 1	>1.3 [1] ≤1.3 [0]	
Collision warning signal automatically ceases in less than [1] second after T_1	0 to 1	Ceases within 1 sec [1] Does not cease/ceases in ≥1s [0]	
Max. Points	**10**	**Total Score**	
		Total Score/Max. Points	

9.3 Nearside Turn Proximity Information signal (NTPI) Scenario

9.3.1 Test Scenario Performance Evaluation

9.3.1.1 The evaluation of the performance of the blind spot system during the Nearside Turn Proximity Information signal (NTPI) test scenarios shall be assessed in accordance with Table 13.

Table 13: Evaluation of test performance for the Nearside Turn Proximity Information signal (NTPI) test scenarios

Test Scenario	Points Available	Result Criteria	Result Metric	Score
All Scenarios (False Positive)	-2 to 0	Proximity information signal status before T_0 in any test scenario	Inactive [0] Active [-2]	
Cyclist Near (True Positive)	0 to 1	Proportion of evaluation distance for which proximity information signal was active	100% Active [1] 100% Inactive [0]	
Cyclist Far (True Positive)	0 to 1	Proportion of evaluation distance for which proximity information signal was active	100% Active [1] 100% Inactive [0]	
All Scenarios (False Positive)	-2 to 0	Collision warning status in any test scenario	Inactive [0] Active [-2]	
Max. Points	**2**		**Total Score**	
			Total Score/Max. Points	

9.4 HMI Performance Evaluation

9.4.1.1 The evaluation of the performance of the blind spot system HMI across all Nearside Turn Proximity Information signal (NTPI) test scenarios shall be assessed according to Table 14.

Table 14: Evaluation of human-machine interface (HMI) performance for the Nearside Turn Proximity Information signal (NTPI) test scenarios

HMI Criteria	Points Available	Result Criteria	Score
Proximity information signal transmitted over the visual mode only	0 to 3	Visual [3] Tonal or Haptic or Speech [0]	
Visual proximity information signal is located within a horizontal field of view angle of 30°-60° towards the nearside of the vehicle, without causing an obstruction to direct or indirect vision	0 to 1	In zone [1] Out of zone [0]	
Visual proximity information signal is amber in colour	0 to 1	Amber [1] Other colour [0]	
Max. Points	**5**	**Total Score**	
		Total Score/Max. Points	

9.5 Nearside Turn Low relative Cyclist speed (NTLC) Scenario

9.5.1 Test Scenario Performance Evaluation

9.5.1.1 The evaluation of the performance of the blind spot system during the Nearside Turn Low relative Cyclist speed (NTLC) test scenarios shall be assessed in accordance with Table 15.

Table 15: Evaluation of test performance for the Nearside Turn Low relative Cyclist speed (NTLC) test scenarios

Test Scenario	Points Available	Result Criteria	Result Metric	Score
Cyclist Near (Proximity Information Signal)	0 to 1	Proportion of proximity test evaluation distance for which proximity information signal was active	100% Active [1] 100% Inactive [0]	
Cyclist Near (Collision Warning)	0 to 2	Proportion of collision test evaluation distance for which collision warning was active	100% Active [2] 100% Inactive [0]	
Cyclist Near (Premature Collision Warning)	-2 to 0	Collision warning status before TP in any test scenario	Inactive [0] Active [-2]	
Cyclist Far (Proximity Information Signal)	0 to 1	Proportion of proximity test evaluation distance for which proximity information signal was active	100% Active [1] 100% Inactive [0]	
Cyclist Far (Collision Warning)	0 to 2	Proportion of collision test evaluation distance for which collision warning was active	100% Active [2] 100% Inactive [0]	
Cyclist Far (Premature Collision Warning)	-2 to 0	Collision warning status before TP in any test scenario	Inactive [0] Active [-2]	
Max. Points	**6**		**Total Score**	
			Total Score/Max. Points	

9.5.2 HMI Performance Evaluation

9.5.2.1 The evaluation of the performance of the blind spot system HMI across all Nearside Turn Low relative Cyclist speed (NTLC) test scenarios shall be assessed according to Table 16.

Table 16: Evaluation of human-machine interface (HMI) performance for the Nearside Turn Low relative Cyclist speed (NTLC) test scenarios

HMI Criteria	Points Available	Result Criteria	Score
Proximity information signal transmitted over the visual mode only	0 to 3	Visual [3] Tonal or Haptic or Speech [0]	
Visual proximity information signal is located within a horizontal field of view angle of 30°-60° towards the nearside of the vehicle, without causing an obstruction to direct or indirect vision	0 to 1	In zone [1] Out of zone [0]	
Visual proximity information signal is amber in colour	0 to 1	Amber [1] Other colour [0]	
Visual proximity information signal ceases automatically on activation of the collision warning signal	0 to 1	Ceases on Activation [1] Does not cease on Activation [0]	
Collision warning signal is transmitted over at least two modes	0 to 1	Multi-mode [1] Single mode [0]	
Collision warning signal is transmitted over at least one of audible/haptic modes	0 to 1	Includes Audible/Haptic Mode [1] No Audible/Haptic Modes [0]	
Collision warning signal uses a different mode to the proximity information signal or is distinctly different in presentation	0 to 1	Different [1] Similar [0]	
Visual collision warning signal is located within a horizontal field of view angle of 30°-60°	0 to 1	In zone [1] Out of zone [0]	

towards the nearside of the vehicle, without causing an obstruction to direct or indirect vision			
Visual collision warning signal is red in colour	0 to 1	Red [1] Other colour [0]	
Audible collision warning signal does not use speech coding	0 to 1	Tonal [1] Speech Coding [0]	
Tonal collision warnings are distinct from other sounds used within the vehicle	0 to 1	Distinct [1] Similar [0]	
Tonal collision warnings have a signal to ambient noise ratio of greater than 1.3 between relevant loudness spectra	0 to 1	>1.3 [1] ≤1.3 [0]	
Collision warning signal automatically ceases in less than [2] seconds after T_1	0 to 1	Ceases within 2 secs [1] Does not cease/ceases in ≥2s [0]	
Max. Points	**15**	**Total Score**	
		Total Score/Max. Points	

9.6 Nearside Turn High relative Cyclist speed (NTHC) Scenario

9.6.1 Test Scenario Performance Evaluation

9.6.1.1 The evaluation of the performance of the blind spot system during the Nearside Turn High relative Cyclist speed (NTHC) test scenarios shall be assessed in accordance with Table 17.

Table 17: Evaluation of test performance for the Nearside Turn High relative Cyclist speed (NTHC) test scenarios

Test Scenario	Points Available	Result Criteria	Result Metric	Score
Cyclist Near (Proximity Information Signal)	0 to 1	Proportion of proximity test evaluation distance for which proximity information signal was active	100% Active [1] 100% Inactive [0]	
Cyclist Near (Collision Warning)	0 to 2	Proportion of collision test evaluation distance for which collision warning was active	100% Active [2] 100% Inactive [0]	
Cyclist Near (Premature Collision Warning)	-2 to 0	Collision warning status before TP in any test scenario	Inactive [0] Active [-2]	
Cyclist Far (Proximity Information Signal)	0 to 1	Proportion of proximity test evaluation distance for which proximity information signal was active	100% Active [1] 100% Inactive [0]	
Cyclist Far (Collision Warning)	0 to 2	Proportion of collision test evaluation distance for which collision warning was active	100% Active [2] 100% Inactive [0]	
Cyclist Far (Premature Collision Warning)	-2 to 0	Collision warning status before TP in any test scenario	Inactive [0] Active [-2]	
Max. Points	**6**		**Total Score**	
			Total Score/Max. Points	

9.6.2 HMI Performance Evaluation

9.6.2.1 The evaluation of the performance of the blind spot system HMI across all Nearside Turn Low relative Cyclist speed (NTLC) test scenarios shall be assessed according to Table 18.

Table 18: Evaluation of human-machine interface (HMI) performance for the Nearside Turn Low relative Cyclist speed (NTLC) test scenarios

HMI Criteria	Points Available	Result Criteria	Score
Proximity information signal transmitted over the visual mode only	0 to 3	Visual [3] Tonal or Haptic or Speech [0]	
Visual proximity information signal is located within a horizontal field of view angle of 30°-60° towards the nearside of the vehicle, without causing an obstruction to direct or indirect vision	0 to 1	In zone [1] Out of zone [0]	
Visual proximity information signal is amber in colour	0 to 1	Amber [1] Other colour [0]	
Visual proximity information signal ceases automatically on activation of the collision warning signal	0 to 1	Ceases on Activation [1] Does not cease on Activation [0]	
Collision warning signal is transmitted over at least two modes	0 to 1	Multi-mode [1] Single mode [0]	
Collision warning signal is transmitted over at least one of audible/haptic modes	0 to 1	Includes Audible/Haptic Mode [1] No Audible/Haptic Modes [0]	
Collision warning signal uses a different mode to the proximity information signal or is distinctly different in presentation	0 to 1	Different [1] Similar [0]	
Visual collision warning signal is located within a horizontal field of view angle of 30°-60° towards the nearside of the vehicle, without causing	0 to 1	In zone [1] Out of zone [0]	

an obstruction to direct or indirect vision			
Visual collision warning signal is red in colour	0 to 1	Red [1] Other colour [0]	
Audible collision warning signal does not use speech coding	0 to 1	Tonal [1] Speech Coding [0]	
Tonal collision warnings are distinct from other sounds used within the vehicle	0 to 1	Distinct [1] Similar [0]	
Tonal collision warnings have a signal to ambient noise ratio of greater than 1.3 between relevant loudness spectra	0 to 1	>1.3 [1] ≤1.3 [0]	
Collision warning signal automatically ceases in less than [2] seconds after T_1	0 to 1	Ceases within 2 secs [1] Does not cease/ceases in ≥2s [0]	
Max. Points	**15**	**Total Score**	
		Total Score/Max. Points	

9.7 Nearside Turn Crossing Pedestrian (NTCP) Scenario

9.7.1 Test Scenario Performance Evaluation

9.7.1.1 The evaluation of the performance of the blind spot system during the Nearside Turn Crossing Pedestrian (NTCP) test scenario shall be assessed according to Table 19.

Table 19: Evaluation of test performance for the Nearside Turn Crossing Pedestrian (NTCP) test scenario

Test Scenario	Points Available	Result Criteria	Result Metric	Score
Pedestrian (Proximity Information Signal)	0 to 1	Proportion of proximity test evaluation distance for which proximity information signal was active	100% Active [1] 100% Inactive [0]	
Pedestrian (Collision Warning)	0 to 2	Proportion of collision test evaluation distance for which collision warning was active	100% Active [2] 100% Inactive [0]	
Pedestrian (Premature Collision Warning)	-2 to 0	Collision warning status before TP in any test scenario	Inactive [0] Active [-2]	
Max. Points	**3**		**Total Score**	
			Total Score/Max. Points	

9.7.2 HMI Performance Evaluation

9.7.2.1 The evaluation of the performance of the blind spot system HMI across all Nearside Turn Low relative Cyclist speed (NTLC) test scenarios shall be assessed according to Table 20.

Table 20: Evaluation of human-machine interface (HMI) performance for the Nearside Turn Crossing Pedestrian (NTCP) test scenario

HMI Criteria	Points Available	Result Criteria	Score
Proximity information signal transmitted over the visual mode only	0 to 3	Visual [3] Tonal or Haptic or Speech [0]	
Visual proximity information signal is located within a horizontal field of view angle of 30°-60° towards the nearside of the vehicle, without causing an obstruction to direct or indirect vision	0 to 1	In zone [1] Out of zone [0]	
Visual proximity information signal is amber in colour	0 to 1	Amber [1] Other colour [0]	
Visual proximity information signal ceases automatically on activation of the collision warning signal	0 to 1	Ceases on Activation [1] Does not cease on Activation [0]	
Collision warning signal is transmitted over at least two modes	0 to 1	Multi-mode [1] Single mode [0]	
Collision warning signal is transmitted over at least one of audible/haptic modes	0 to 1	Includes Audible/Haptic Mode [1] No Audible/Haptic Modes [0]	
Collision warning signal uses a different mode to the proximity information signal or is distinctly different in presentation	0 to 1	Different [1] Similar [0]	
Visual collision warning signal is located within a horizontal field of view angle of 30°-60° towards the nearside of	0 to 1	In zone [1] Out of zone [0]	

the vehicle, without causing an obstruction to direct or indirect vision			
Visual collision warning signal is red in colour	0 to 1	Red [1] Other colour [0]	
Audible collision warning signal does not use speech coding	0 to 1	Tonal [1] Speech Coding [0]	
Tonal collision warnings are distinct from other sounds used within the vehicle	0 to 1	Distinct [1] Similar [0]	
Tonal collision warnings have a signal to ambient noise ratio of greater than 1.3 between relevant loudness spectra	0 to 1	>1.3 [1] ≤1.3 [0]	
Collision warning signal automatically ceases in less than [2] seconds after T_1	0 to 1	Ceases within 2 secs [1] Does not cease/ceases in ≥2s [0]	
Max. Points	**15**	**Total Score**	
		Total Score/Max. Points	

9.8 Nearside Turn No test Target (NTNT) Scenario

9.8.1 Test Scenario Performance Evaluation

9.8.1.1 The evaluation of the performance of the blind spot system during the Nearside Turn No test Target (NTNT) test scenario shall be assessed in accordance with Table 21. No assessment of the HMI performance shall be performed for the Nearside Turn No test Target (NTNT) test scenario.

Table 21: Evaluation of test performance for the Nearside Turn No test Target (NTNT) test scenario

Test Scenario	Points Available	Result Criteria	Result Metric	Score
Proximity Information Signal (False Positive)	-1 to 0	Proximity information signal status in any test scenario	Inactive [0] Active [-1]	
Collision Warning (False Positive)	-2 to 0	Collision warning status in any test scenario	Inactive [0] Active [-2]	
Max. Points	**0 (min -3)**		**Total Score**	
			Total Score/Max. Points	

9.9 General HMI Evaluation

9.9.1 Formal independent tests need not be undertaken in respect of the additional HMI requirements specified in Table 22. Assessment may be based on documentary evidence provided by the system supplier and demonstration of functionality. The general HMI parameters that attract additional credit are identified in Table 22.

Table 22: Requirements for warning systems

HMI Criteria	Points Available	Result criteria	Score
The device automatically switches off above a speed of 30 km/h	0 to 1	Switches Off [1] Does Not Switch Off [0]	
The operational status of the device is communicated to the driver	0 to 1	Status Communicated [1] Status Not Communicated [0]	
Visual displays use colour combinations recommended by ISO 15008:2009	0 to 1	Recommended [1] Not recommended [0]	
Visual displays shall have a brightness of ≥6000 cd/m² in daylight conditions	0 to 1	≥6000 cd/m² [1] <6000 cd/m² [0]	
Visual displays have a (manually or automatically) adjustable brightness to compensate for ambient conditions	0 to 1	Adjustable [1] Fixed [0]	
Visual displays are of sufficient size with minimum dimensions of 12 mm x 12 mm on driver side and 20 mm x 20 mm on passenger side of vehicle	0 to 1	Sufficient Size [1] Insufficient Size [0]	
Max. Points	**6**	**Total Score**	
		Total Score/Max. Points	

9.9.2 Motion inhibit systems shall be over-rideable by the driver to continue making progress in the event of a false positive

9.10 Quality, Durability and Installation Requirements

9.10.1 Additional score will be awarded if the system or vehicle supplier can demonstrate documentary evidence of compliance with the requirements in Table 23.

Table 23: Requirements for Quality, Durability and Installation

Criteria	Points Available	Result criteria	Score
Complies with EN50498 for Electro-Magnetic Compatibility	0 to 1	Compliant [1] Not Compliant [0]	
Complies with UNECE Regulation 10.04 for immunity to radio frequency interference (RFI)	0 to 1	Compliant [1] Not Compliant [0]	
Complies with ISO 11452-9 or ISO 11451-3	0 to 1	Compliant [1] Not Compliant [0]	
Complies with the Mechanical Test aspects of ISO 16001	0 to 1	Compliant [1] Not Compliant [0]	
Complies with the Mechanical Test aspects of ISO 15998	0 to 1	Compliant [1] Not Compliant [0]	
Max. Points	**5**	**Total Score**	
		Total Score/Max. Points	

9.11 Overall Rating

9.11.1 Each of the individual assessments defined across the previous sections will provide a normalised performance score between 0 and 1. Due to the characteristics of the London collision landscape, however, some test scenarios are deemed to be more important than others for preventing bus-to-VRU collisions. These individual scores are, therefore, weighted by importance then summed together to produce an overall Blind Spot information signal, Warning and intervention (BSW) performance score between 0% and 100%, as shown in Table 24.

Table 24: Weightings for overall Blind Spot information signal, Warning and intervention (BSW) performance rating score

Scenario	Evaluation Method	Evaluation Score (E)	Scenario Weighting	Collision Population Weighting	Scenario Weighting	Evaluation Method Weighting	Overall Weighting (W)	Weighted Score (W*E)
Moving-Off Proximity Information signal (MOPI)	Performance		90%	57%	45%	75%	0.173	
	HMI					25%	0.058	
Moving-Off collision Warning and motion Inhibit (MOWI)	Performance		90%	57%	55%	95%	0.268	
	HMI					5%	0.014	
Nearside Turn Proximity Information signal (NTPI)	Performance		90%	15%	20%	75%	0.020	
	HMI					25%	0.007	
Nearside Turn Low relative Cyclist speed (NTLC)	Performance		90%	15%	30%	75%	0.030	
	HMI					25%	0.010	
Nearside Turn High relative Cyclist speed (NTHC)	Performance		90%	15%	30%	75%	0.030	
	HMI					25%	0.010	
Nearside Turn Crossing Pedestrian (NTCP)	Performance		90%	28%	100%	75%	0.189	
	HMI					25%	0.063	
Nearside Turn No test Target (NTNT)	Performance		90%	15%	20%	75%	0.020	
	HMI					25%	0.007	
Additional HMI Requirements			5%				0.050	
Quality, Durability & Installation			5%				0.050	
Overall BSW Performance Rating Score (%)								

10 Test Report

10.1 The Test Service shall provide a comprehensive Test Report that will be made available to TfL. The test report shall consist of three distinct sections:

a) Performance data

b) Confirmation of protocol compliance

c) Reference information

10.2 The minimum performance data required is the completion of each table of results listed in this document.

10.3 In order to confirm protocol compliance, the Test Service shall:

a) include in the report processed data (e.g. graphs, tables etc.) that show that each test was compliant with its associated variables and tolerances

b) provide data on environmental validity criteria, including temperature, weather and lighting measurements, demonstrating compliance with respective limit values.

10.4 The reference information required includes as a minimum:

a) Vehicle Make

b) Vehicle Model

c) Vehicle Model Variant

d) BSW Hardware version (e.g. sensor types, ECU references)

e) BSW Software version

Attachment 25: Blind Spot Warning Guidance Notes

1 Introduction

Separate requirements are intended to ensure that drivers have a good field of view from a bus in respect to vulnerable road users (VRUs) in close proximity to the bus. The aim of the Blind Spot information signal, Warning and intervention (BSW) safety measure is to recognise that good vision alone will not guarantee that drivers will successfully avoid all collisions with VRUs in close proximity to buses performing low speed manoeuvres. Information signals, warnings and interventions based on the detection of vulnerable road users through electronic sensing systems can, therefore, still have a significant potential benefit in these circumstances.

This document sets out the guidance notes related to the testing and assessment of the safety performance of BSW systems. These guidance notes are aimed at bus operators and manufacturers as a practical guide for implementation of the Bus Safety Standard.

These notes are for guidance only, and are not legally binding. In all circumstances, guidance provided by the manufacturer of a bus or system shall take precedence, and these guidance notes are only for use in the absence of other information. These are not intended to be exhaustive, but to point the operators toward practical advice and questions to raise with manufacturers/suppliers.

2 Selection of buses/systems

Any bus that meets the TfL Bus Vehicle Specification.

The blind spot information warning and intervention (BSW) requirements may be assessed against a new build bus with functions integrated in the factory by the bus OEM, or against a vehicle fitted with a system supplied by an organisation other than a bus OEM either for dealer fit or as an aftermarket fitment.

2.1 Compliance and warranty

A bus operator should seek evidence from the system supplier and/or bus manufacturer that a dealer fit or aftermarket fitted device does not create any warranty problems for the bus OEM. Operators should also be aware that a regulation governing the technical standards of systems with some of the functionality described in the assessment is in development and will be applied to HGVs. It is possible that this may be extended to buses, but any regulatory requirements will only apply to new buses first registered from the relevant future date. It will not render devices fitted before that time illegal, even if they do not comply with the new requirements.

2.2 Interpreting the requirements and selecting the most effective way to fulfil them

In order to recognise a potentially dangerous situation during low speed manoeuvres and successfully avoid a collision, then the following elements are required:

- **Available to be seen:** The hazard (pedestrian, cyclist, other vehicle etc.) needs to be available to be seen by the driver sufficiently ahead of time to allow avoiding action to be taken. That is, the hazard needs to be in view at least around 2 seconds before collision.
- **Alert and attentive:** The driver needs to be attentive to the road and traffic environment and alert to the possible need to react.
- **Looking in the right direction**: In complex driving situations, the driving task can demand attention in multiple different directions; the driver needs to be looking in the right direction at the right time to see the hazard. In dynamic moving environments this is not guaranteed even if the driver is alert and attentive.
- **Recognition:** Once the hazard is seen, then the driver must recognise the hazard and the risk that it poses.
- **Reaction:** Once the risk is recognised, the driver must react quickly and correctly to the risk. In some circumstances this may be steering around the hazard, in many it will be braking the vehicle to a stop and in others it might simply be to remain stationary instead of moving off from rest.

Thus, the ability to avoid a collision in the low speed manoeuvring circumstances envisaged for BSW systems is also strongly related to the vision performance of the bus and so the two safety measures should be considered together so that they are complementary and work in synergy.

BSW systems can supplement the vision requirements in circumstances where the hazard is still unavailable to be seen by the driver. However, the main benefit is likely to be in drawing the drivers attention to the presence of the hazard when, either for legitimate reasons of driver workload or for reasons of distraction or fatigue, the driver is not looking in the direction of the hazard at the exact time needed to avoid collision. In these circumstances the BSW can draw the driver attention to the right spot at the right time where the hazard will be visible in direct or indirect vision such that it maximises the chance of prompt recognition and correct reactions.

In order to achieve this, the way that the systems interact with the driver to inform them, warn them or intervene on their behalf is considered critical to the likely success of the system. This aspect of system design is known as the human-machine interface, or HMI. Measures are in place to encourage good HMI in the test and assessment protocol and are based on established industry standards (e.g. ISO standards). They are typically related to the criticality of the driving situation (is a collision likely in the next couple of seconds, in a longer period or not necessarily likely at all) and the urgency of the warning. However, HMI has inevitable subjective elements and can be difficult to measure objectively so there will still be room for substantial variation in the systems available on the market. The guidance below provides both the rationale for the protocol requirements and information to help operators choose systems that they believe will work well with their vehicles, in the operating environments the vehicles will be used in and by their drivers.

2.3 Proximity information signals

Proximity information signals are systems that will inform the driver any time a vulnerable road user is in close proximity to the vehicle. In London traffic these will be issued very frequently. In the vast majority of these situations, the situation will not be critical i.e. a collision will not be imminent in the next couple of seconds and the driver may well already be well aware of the presence of the hazard. Thus, reaction to non-critical situations should be discouraged and the warning should not be urgent or intrusive. In these circumstances an urgent, intrusive warning such as a loud tonal sound, a buzzer etc. can be annoying to the driver. They may subconsciously tune the warning out such that they ignore it when it is really needed or they may even find ways of disabling the system. Thus, examples of amber visual warnings may be much more acceptable to the driver in the many cases where the situation is not critical and/or they were already aware, while still providing useful information about the presence of hazards, when they are hidden or the driver has not seen them.

2.4 Collision warnings

Collision warnings should be issued only when the driving situation is critical i.e. the system has calculated that a collision is imminent in the next few seconds. Thus, even in London traffic they should go off far less frequently than proximity warnings. In this case, it is necessary for the warnings to be urgent and intrusive because they must quickly grab the attention of the driver and provoke rapid action to prevent a collision. These intrusive warnings are far less likely to annoy the driver, firstly because they should be far less frequent than proximity warnings and secondly because if they are working well it should be possible for the driver to see the reason for the warning in the majority of instances. False or premature activations when either the system has misdiagnosed the situation or reacted too soon will undermine driver confidence in the system and should be minimised, though what constitutes ‘too soon’ or even ‘false’ is to some degree subjective and driver dependent.

As such warnings issued over more than one channel (e.g. audible and visual and/or haptic warnings that are felt such as vibrations) are desirable, and speech warnings are undesirable because they take a finite time to complete and the drivers take a finite amount of time to process and understand the warning. Visual warnings should be red and audible warnings sufficiently loud to be heard against the backdrop of engine/passenger noise etc.

2.5 Other alert/warning signals

It should be noted that the test and assessment protocol only considers information signals and collision warnings in relation to close proximity manoeuvring but system suppliers may offer such signals in other driving circumstances, for example in relation to lane departure or imminent collision with a vehicle ahead. The requirements of the Bus Vehicle Specification and the test and assessment protocol do not apply to these other functions but also do not prohibit them. You can have other functions on the vehicle if considered beneficial. However, operators should consider the same HMI principles in relation to these other warnings and consider driver workload, recognition and reaction issues in terms of how well the system communicates the type of hazard to the driver such that it maximises the chance of a quick and correct response and avoids driver confusion. Having very similar anonymous bleeps in reaction to multiple different undesirable traffic situations is unlikely to maximise driver effectiveness in collision avoidance.

2.6 Signal directionality and workload

Systems that draw the driver's attention in the direction of the hazard are considered more desirable than those that do not. For example, a system detecting the proximity of a cyclist to the left of the bus might illuminate an amber visual warning at the left side of the bus. By contrast a system that issues an audible and visual collision warning at a point low down in the dashboard near the driver, actually draws driver attention away from the hazard and may well be less effective as a consequence and generally increase driver workload.

2.7 Intervention systems

Even with the best vision and a high quality warning, successful collision avoidance will still rely on the driver taking the correct course of action sufficiently quickly and is, therefore, not guaranteed. Intervention systems will act in the event that the driver does not make the correct avoidance action or makes it insufficiently quickly. There are also clear risks with intervention systems if, for example, they misdiagnose the situation and intervene when they should not.

At the time of drafting requirements, it should be noted that automated emergency braking systems that are active in low speed manoeuvres (i.e. <10 km/h), particularly during left or right turns, were not available for any vehicle type. Although it is known that prototypes are in development, technical challenges remain around sensor accuracy, sensor fields of view and brake build up times, so it is not clear when they would be available. These have therefore not been included in the bus safety standard. However, such systems are not prohibited and if they become available should be analysed, assessed and considered.

Collisions where the vehicle moves off from rest and hits a pedestrian immediately in front of the vehicle present a particular challenge. In HGVs they are thought to occur because of blind spots. Buses typically do not suffer from such blind spots but collisions do still occur, albeit relatively less frequently. One possible explanation for this is that the driver is legitimately looking over their shoulder to check it is clear to move out from a bus stop into traffic at the time they move off. A non-intrusive visual warning may or may not be sufficient to draw the attention of the driver to the hazard given how far away from the relevant direction they may be looking.

By definition, a collision warning can only activate once the vehicle first moves such that it is on a collision course. If the pedestrian is close to the front, this would be issued too late for the driver to react and stop before the collision, though it may still prevent runover by the wheels.

However, a system that detected the presence of a pedestrian and, for example, disabled the throttle, then a driver that had not seen the pedestrian would remain unable to move the vehicle. Given that the vehicle would at this time be stationary, and probably would have been for some time, then the risks of such an intervention are relatively low. In the event of a spurious activation, the procedure allows for a driver over-ride to prevent the vehicle being 'marooned'. The aim is that it should not be so easy to activate that it could be done accidentally but not so complicated that the driver would forget how to do it. Driver over-ride should only be activated when the driver is absolutely confident there is no hazard immediately in front of the vehicle. The over-ride function should deactivate once the system determines that the detected hazard has been avoided.

3 Training

3.1 For test houses

Test houses accredited to undertake Euro NCAP AEB tests will have the skills and equipment required for these tests. Test houses without such accreditation will be required to demonstrate to TfL at their expense that they can achieve the same standard of testing as an accredited organisation.

3.2 Bus drivers

Drivers should be familiarised with the system such that they know what any warnings mean and, where applicable, how to over-ride an intervention system and when to do so. They should also be trained to understand the circumstances where the system can help them and those where it can't, for example, if a system does not perform at night or in adverse weather.

3.3 Shift Supervisors

Supervisors should also be familiar with systems such that they can answer any questions from drivers and recognise any problems that may require maintenance.

3.4 Bus maintenance engineers

The engineers carrying out general bus maintenance should be aware of the location and details of the sensors and warning displays/tell tales. They should be trained in any routine maintenance required (e.g. keeping sensors clean, free from obstruction etc.) and how to fault find and repair the system.

4 Maintenance

Operators are encouraged to establish what (if any) daily checks are required, and to plan for these additional operational costs.

5 Repair

If the driver or anyone else reports a failure or a problem with the system this should be investigated and, if confirmed, repaired.