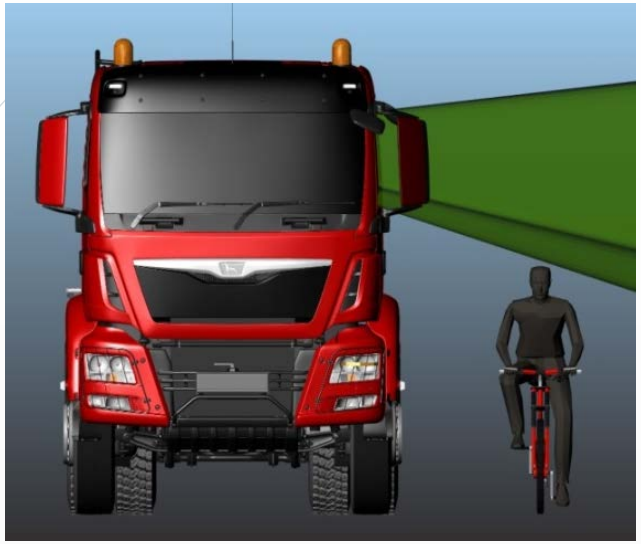
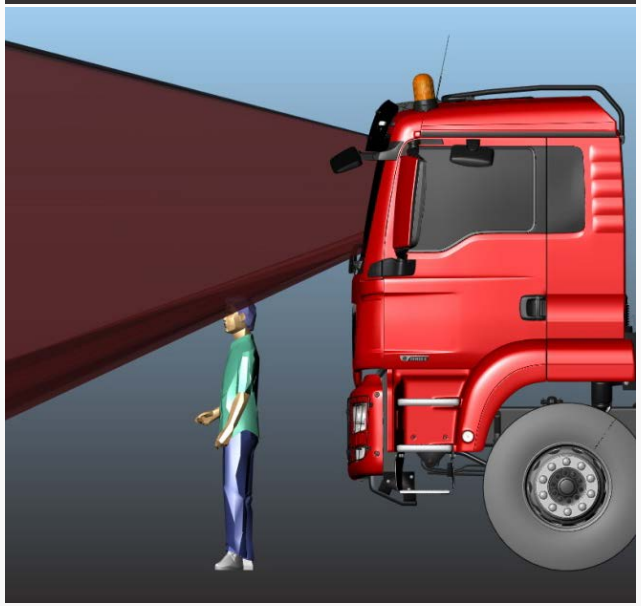
An Independent Test Procedure for Heavy Goods Vehicle Blind Spot Safety devices

GRSG VRU-Proxi Bast 18th/19th July 2017

What is the problem that needs to be solved?





- Unseen pedestrians & cyclists injured by an HGV manoeuvring at low speed - ‘blind spot’ collisions. Two main crash mechanisms identified:
  - VRU (mainly pedestrians) killed at front of HGV when it moves off from rest.
  - VRU (mainly cyclists) killed at the side of an HGV when it turns left (right in EU)
- About equally important
- Small number of collisions at offside turning right

Research Programmes

Direct Vision Protocol development

- Sponsored by TfL
- Contractor: TRL/AVS

Blind Spot Safety systems

- Sponsored by TfL
- Contractor: Thatcham Research, LowCVP, AVS, MIRA

Direct Vision Casualty impact Assessment

- Sponsored by TfL
- Contractor: TRL/AVS

TRANSPORT FOR LONDON
EVERY JOURNEY MATTERS

TRL THE FUTURE OF TRANSPORT

Thatcham Research
BJR SOLUTIONS
SAFETY, SUSTAINABILITY, PROFESSIONALISM

A HORIBA COMPANY MIRA

ETCC Associates

Apollo Vehicle Safety
Automotive Research and Consultancy

Vulnerable Road User (VRU) Collisions In London

Collision & vehicle type	Average number of fatalities per year (2005-2014)	
	Pedestrian	Pedal Cyclist
All collision types	82	15
Collision involving HGV>3.5t	11	5.3
Of which, involving HGV≥7.5t	9	4.7
HGV ≥7.5t 'Moving off from rest'	3	1
HGV ≥ 7.5t 'Turning left'	1	3

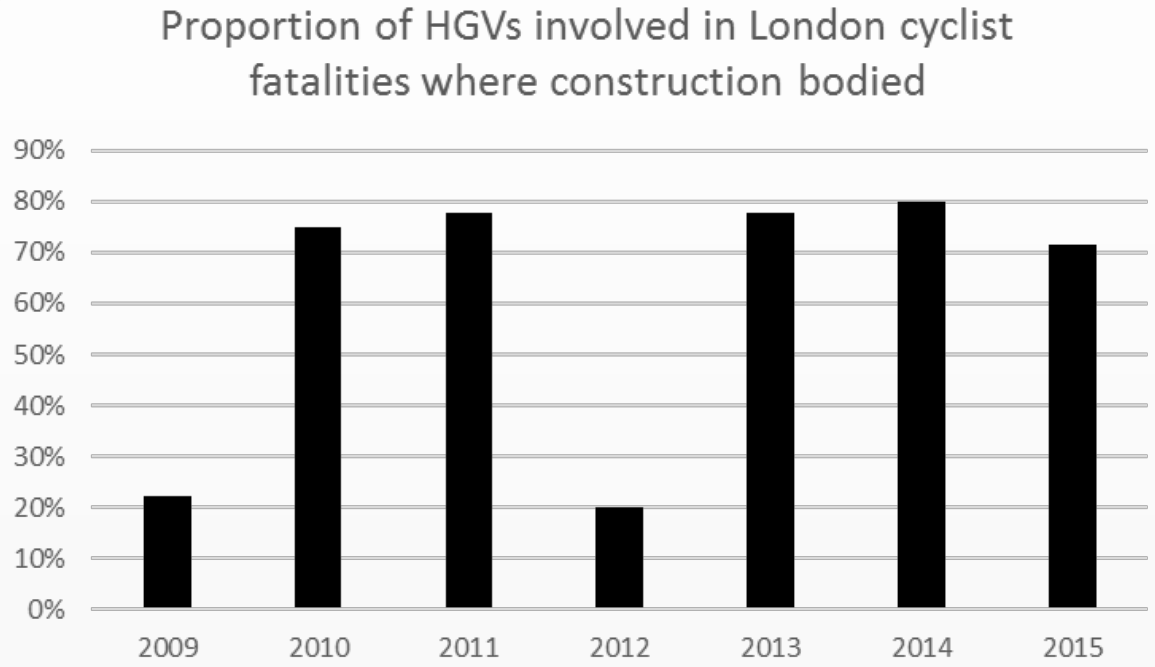
- Overall, pedestrians are a larger problem than cyclists
- Substantial annual variation in numbers (pedestrians 4-14; cyclists 2-9)
- Blind spots are a common contributory factor, particularly for moving off/ turning left
- Pedestrian and cyclist approximately equal in low speed manoeuvre
- Mis-coding may underestimate:
  - Tfl data suggests average 2 PC + 2 Ped fatalities/year in collision with construction HGV mis-coded as 'other'
  - **+50%!**

The Disproportionate Involvement Of HGVs>7.5T and Construction Bodied HGVs

4% London **traffic**

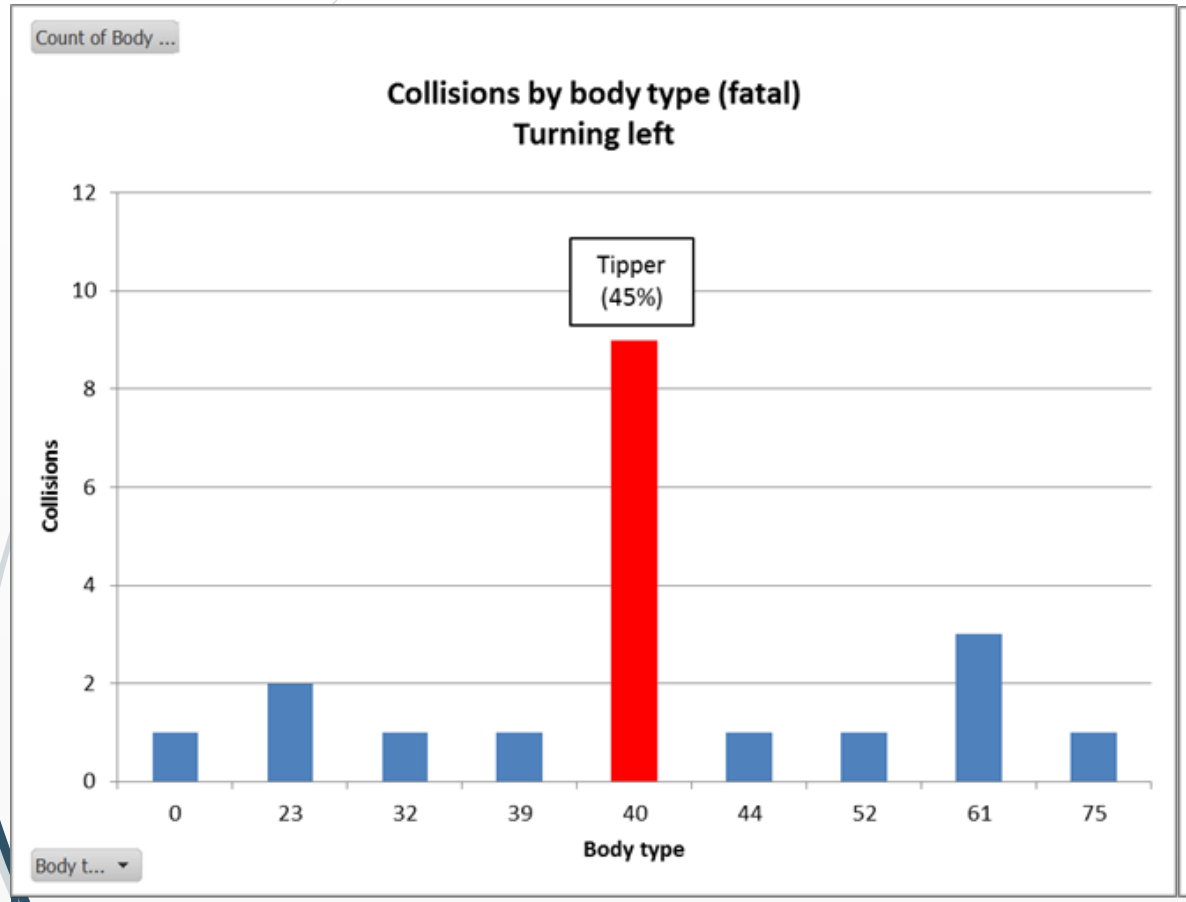
21% of London **Pedestrian** fatalities [5-24%]

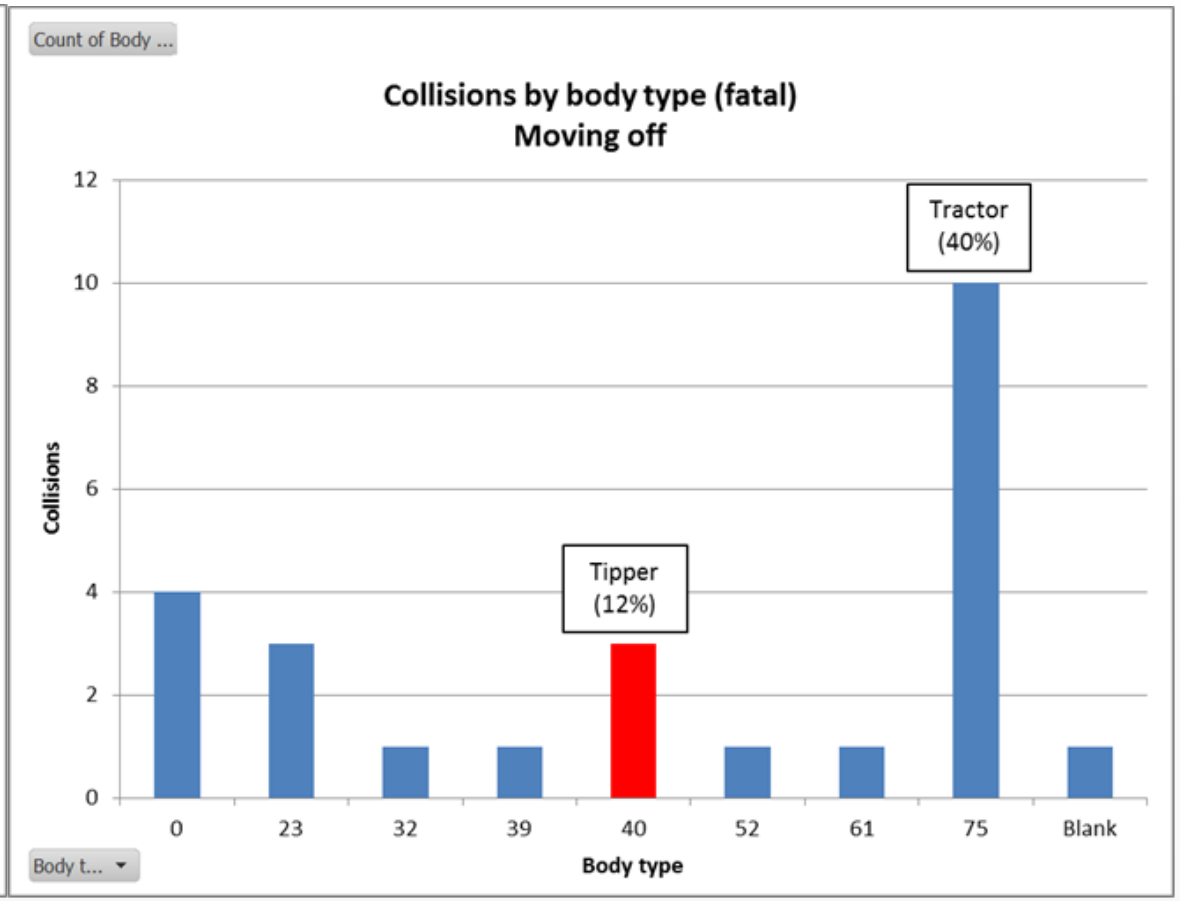
50% of London **Pedal Cycle** fatalities [26-60%]



Note: Averages based on TfL data including miscoded 'others', which is only available for limited years. Ranges based on extremes from standard Stats19 (2005-15) and sample years for TfLs correction of miscoding

Collisions by Body type





Dynamics of Left Turn Collisions

Type 1

- Both HGV and cycle move off from rest together, HGV Turns left
- Impact point typically nearside front
- c.**30% of Cyclist Left turn fatalities** (n=18 in-depth fatal cases)
- ALL stopped at lights/give way before impact

Type 2

- Cyclist moves up inside of stationary HGV at speed. HGV moves off and turns left
- Impact point typically nearside front
- c.**40% of Cyclist Left turn fatalities**
- **ALL stopped at lights/give way before impact**

Type 3

- HGV and cycle both moving, sometimes cycle undertaking, sometimes HGV overtaking, low relative speed, HGV Turns left
- Impact point anywhere along full length
- c.**30% of Cyclist Left turn fatalities**
- **None stopped at lights/give way before impact**

Source: Thatcham Research sponsored by TfL

Application Outside London

Collision & vehicle type	Average number of fatalities per year (2005-2014)	
	London Pedestrian	**GB** Pedestrian
All collision types	82	519
Collision involving HGV>3.5t	11	62
Of which, involving HGV≥7.5t	9	53
HGV ≥7.5t 'Moving off from rest'	3	10
HGV ≥ 7.5t 'Turning left'	1	3

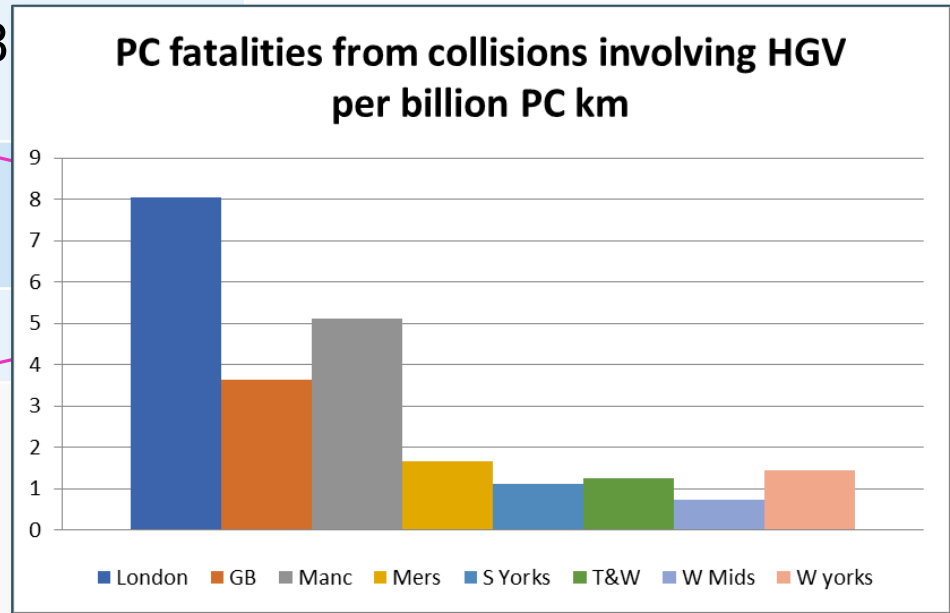
- London sees 1/3 of relevant GB pedestrian collisions

Application Outside London

Collision & vehicle type	Average number of fatalities per year (2005-2014)	
	London Pedal Cyclist	**GB** Pedal Cyclist
All collision types	15	121
Collision involving HGV>3.5t	5.3	22
Of which, involving HGV≥7.5t	4.7	18
HGV ≥7.5t 'Moving off from rest'	1	2
HGV ≥	3	7

- London sees 1/2 of relevant GB pedal cyclist collisions

It happens everywhere, but London suffers more severely, and its not just related to high pedal cycle exposure



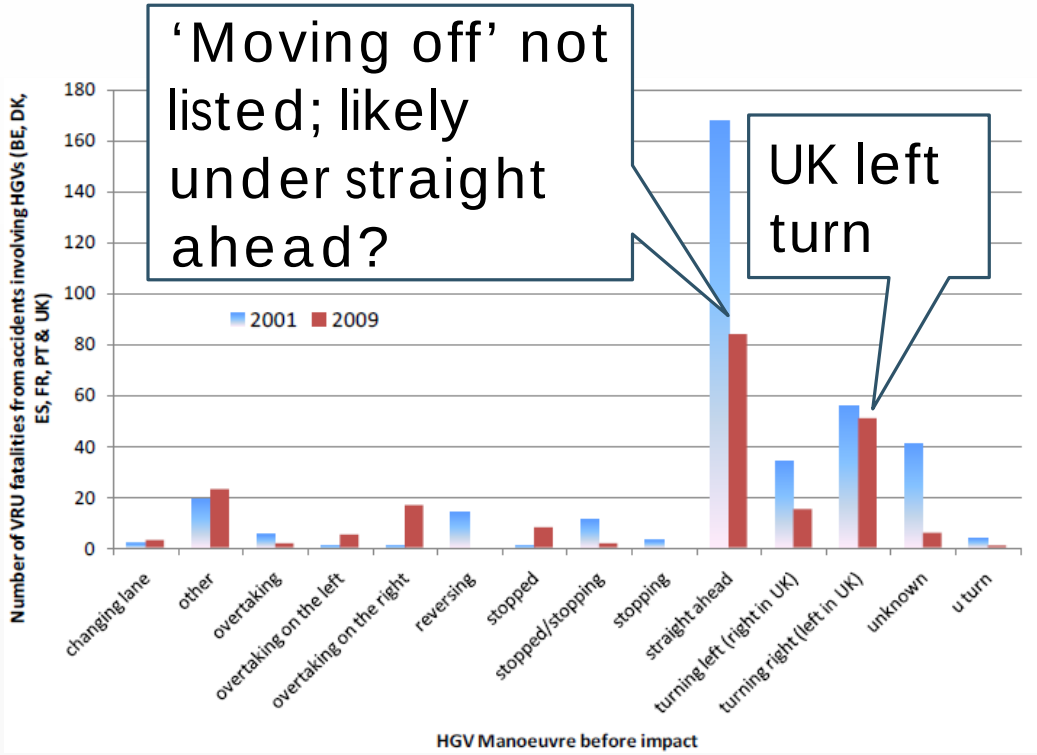
Application Across Europe

- Clear evidence of the turning problem exists across EU
  - c. 20% of HGV-VRU
- Moving off from rest exists but may be less prevalent than UK
  - c. 5% of HGV-VRU

Source: Volvo Trucks Safety Report 2017

- Study on revised Truck Front End Design (TFED) for EC DG Grow estimates:
  - 278 fatal
  - 302 – 670 serious
- Pedestrian/Cyclist EU casualties in move off/turn left collisions

Source: CARE data (2015) combined with literature



Source: CARE data in Knight (2011) assessing retrofit mirrors directive

Application Across Europe: Differences in Left Turn Manoeuvres

UK (Robinson et al, 2016)

- Mostly rigid vehicles
- Often stop at lights prior to collision
- Lateral expected to be small

Germany (Schreck & Seiniger, 2014)

- Mostly articulated vehicles
- Rarely stop before collision
- Lateral separation can be 4m+

Unclear which is representative for EU; shows similar outcomes occur on different infrastructure classes

Blind spot sensors: Why was an independent test procedure needed?

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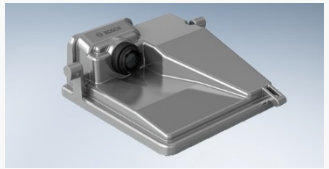
Which has highest casualty reduction potential?



Categorising the systems in scope

Field of View Aid

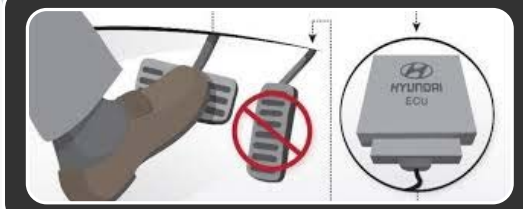
- Technically, any system that helps enable a VRU in close proximity to be seen
- However, direct vision and blind spot mirrors excluded because dealt with elsewhere

Proximity warning

- System that uses sensors to detect the presence of a VRU close to the vehicle and warns the driver
- Warning sounds whenever VRU is present irrespective of whether vehicles are on a collision path

Collision warning

- System that uses sensors to assess the trajectories and speeds of both vehicles and warns when it calculates a collision is imminent



Motion Inhibit

- A system that prevents a vehicle moving off from rest when sensors detect a vulnerable road user in close proximity to the front of the vehicle

Principles guiding design of tests

- Realistic & Representative
  - Road trials representative of normal driving but chances of encountering a collision scenario in short certification test is (fortunately!) very low
  - Design off-road tests that closely represent typical collision scenarios
- Objective, Repeatable and Reproducible
  - Road trials are highly variable, so are humans
  - Use measurements, not judgements
  - Use robot controlled ‘dummies’ to simulate humans and apply consistent steering
- Include consideration of HMI and False Positive
  - User feedback suggested high levels of driver irritation with some systems leading to disabling of system

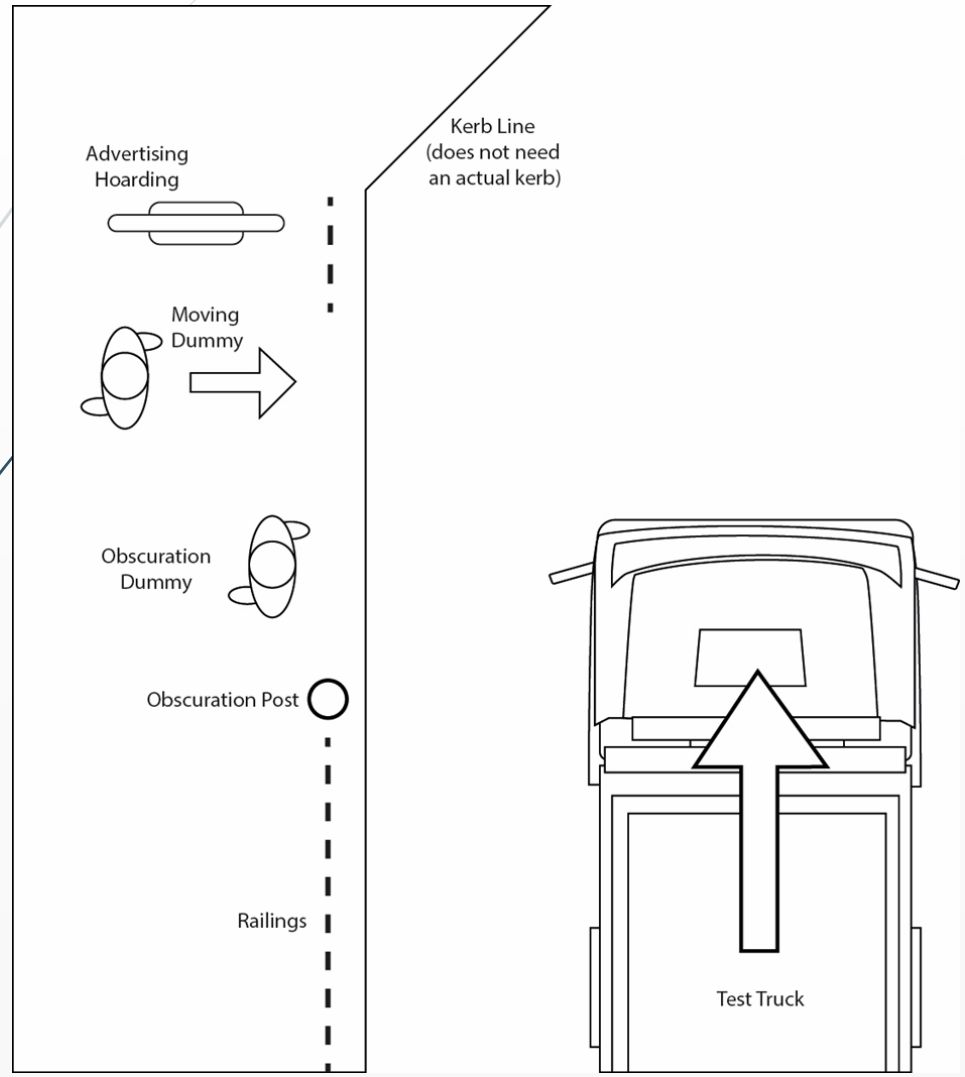
Test scenarios for each safety application

	Collision scenario	Test Method	Blind spot safety application			
			Field of View Aid	Proximity warning	Collision Warning	Motion Inhibit
Test Methods Required	Moving Off	Proximity	✓	✓	✗	✗
		Collision	✗	✗	✓	✓
	Left turn	Detection in presence of clutter	✗	✓	✗	✗
		HGV & VRU move off together	✓	✓	✓	✗
		VRU undertaking an HGV	✓	✓	✓	✗
		False Positive, left turn without VRU	✗	✓	✓	✗
		False Positive: HGV proceeds straight ahead	✗	✓	✓	✗
	Universal	Additional HMI	✓	✓	✓	✓
		Quality, durability, and installation	✓	✓	✓	✓

Note: HMI = Human Machine Interface

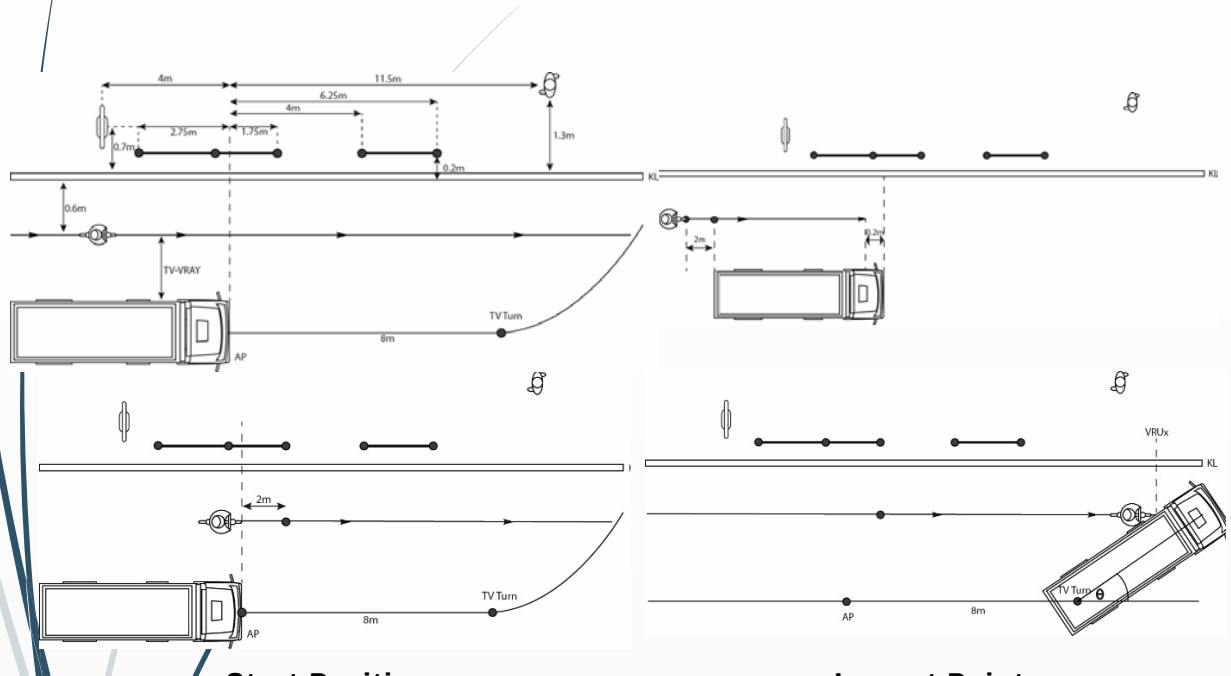
- Multiple tests and assessments undertaken
- Aim is to encourage
  - Good physical detection capability
  - Ability to separate vulnerable road users from railings, signs etc
  - Minimising false positives
  - Employing good HMI to communicate warnings effectively to driver
- Not all tests applicable to all technologies

Test set up: Moving off from rest

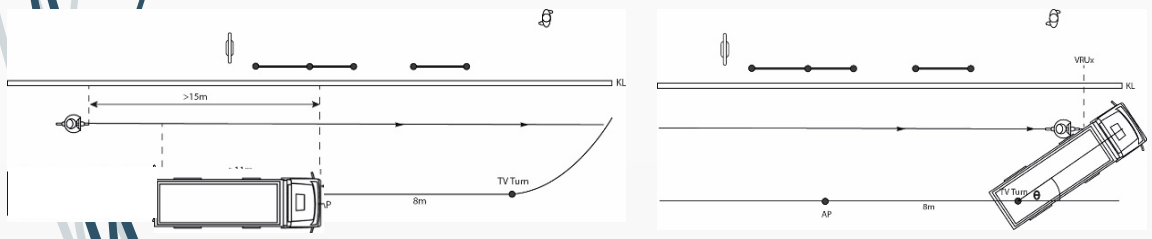


- With Vehicle Stationary aim to detect and warn in response to
  - Adult crossing 0.3m in front
  - Child [3.5m] in front
- Do not respond to
  - Adult [3.5m] in front
  - Any clutter (railings, post hoardings etc)
  - Pedestrian until it moves in direction of vehicle
- With Pedestrian stationary in front of vehicle attempt to move forward
  - Start inhibit marks if cannot move (over-rideable)

Test Set-up: Left turn



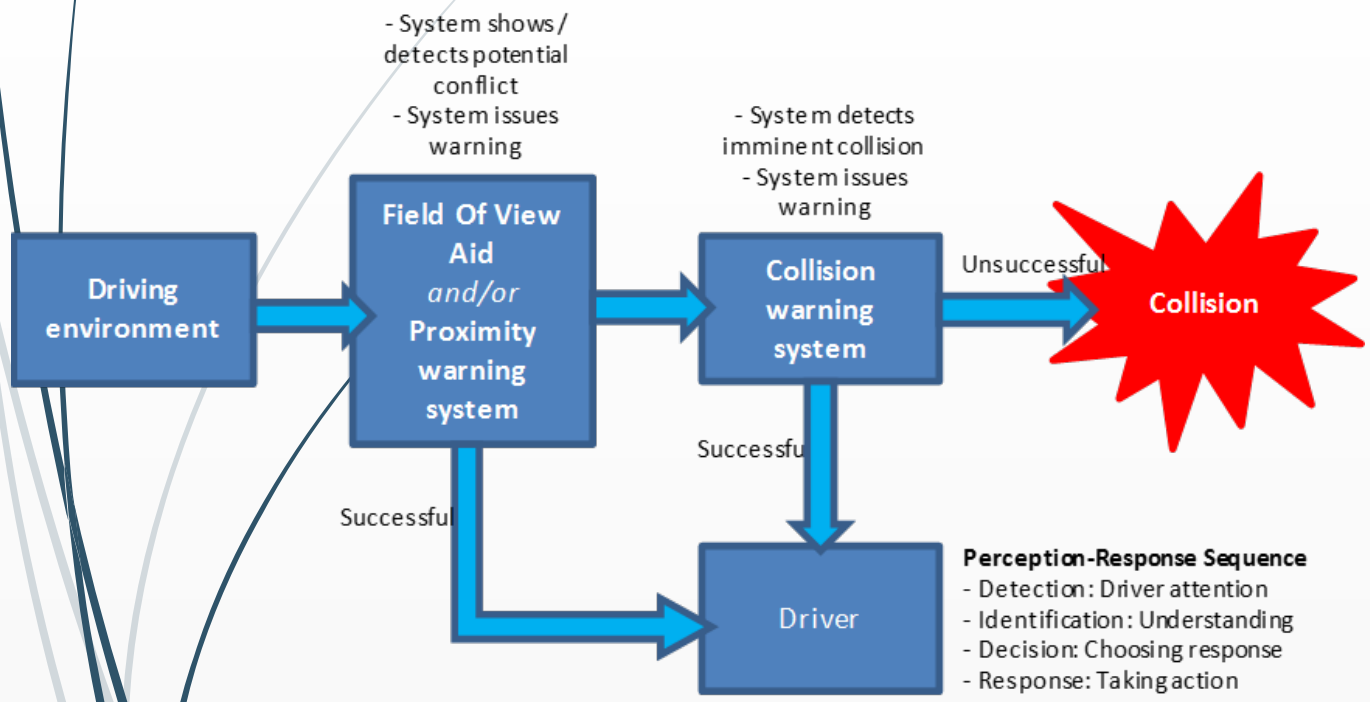
Start Position **Impact Point**



Start Position **Impact Point**

- Detection in presence of clutter: HGV stationary 0.6m-1.5m away from kerb edged with metal railing. No warning until cyclist moves up inside and then warn
- True Positives: Left turn manoeuvres when moving off together and when cyclist approaching from rear
  - lateral separation 0.6m-1.5m
  - Test vehicle speed 10 km/h
  - VRU speed 6-18 km/h
- False positive: No warning when vehicle only passes, no turn, or where vehicle turns but no VRU (i.e. do not respond to kerbside clutter/pedestrian)

HMI Principles



- Adapted from a range of existing automotive standards (e.g. ISO etc). Should be:
  - Noticeable in the driving environment
  - Distinguishable from other messages
  - Indicative of direction of hazard
  - Proportional to urgency of hazard
  - Timely
  - Low nuisance level
  - Accepted by users

How does the driver react?

Example HMI Criteria

Evaluation	Points Available	Result criteria
Proximity warning is issued over a single mode only (visual, audible or haptic).	3 0	Single mode Multi-mode
The warning mode for proximity is visual or speech	1 0	Visual or speech Tonal or Haptic
Visual proximity warnings are located within 15 cm of the upper, lower or forward facing edges of the passenger door window forward of the centre of the drivers seat base in its mid-point adjustment, without causing a visual obstruction to direct or indirect vision	1 0	In zone Out of zone
Visual proximity warnings are amber in colour	1 0	Amber Other colour
Speech warnings specify location of VRU (front, left side, right side)	1 0	Location specified Not specified
Speech warnings comprise less than 6 words and take less than 2 seconds to complete	1 0	<6 words and 2s 6+ words or 2+s
Collision warnings are issued over more than 1 mode	0 1	Single mode [0] Multi-mode [1]
Collision warnings are issued over at least 1 of Audible (Tonal) and Haptic modes.	1 0	Includes tonal and/or Haptic [1] Does not include tonal and/or Haptic [0]
Visual collision warnings are located within 15 cm of the upper, lower or forward facing edges of the passenger door window forward of the centre of the drivers seat base in its mid-point adjustment, without causing a visual obstruction to direct or indirect vision	1 0	In zone [1] Out of zone [0]
Visual collision warnings are red in colour	1 0	Red [1] Other colour [0]
Audible tonal warnings have a signal to ambient ratio of specific loudness spectra greater than 1.3	1 0	≥1.3 [1] < 1.3 [0]
Max points available	12	Total score
		Total Score/Total Points Available

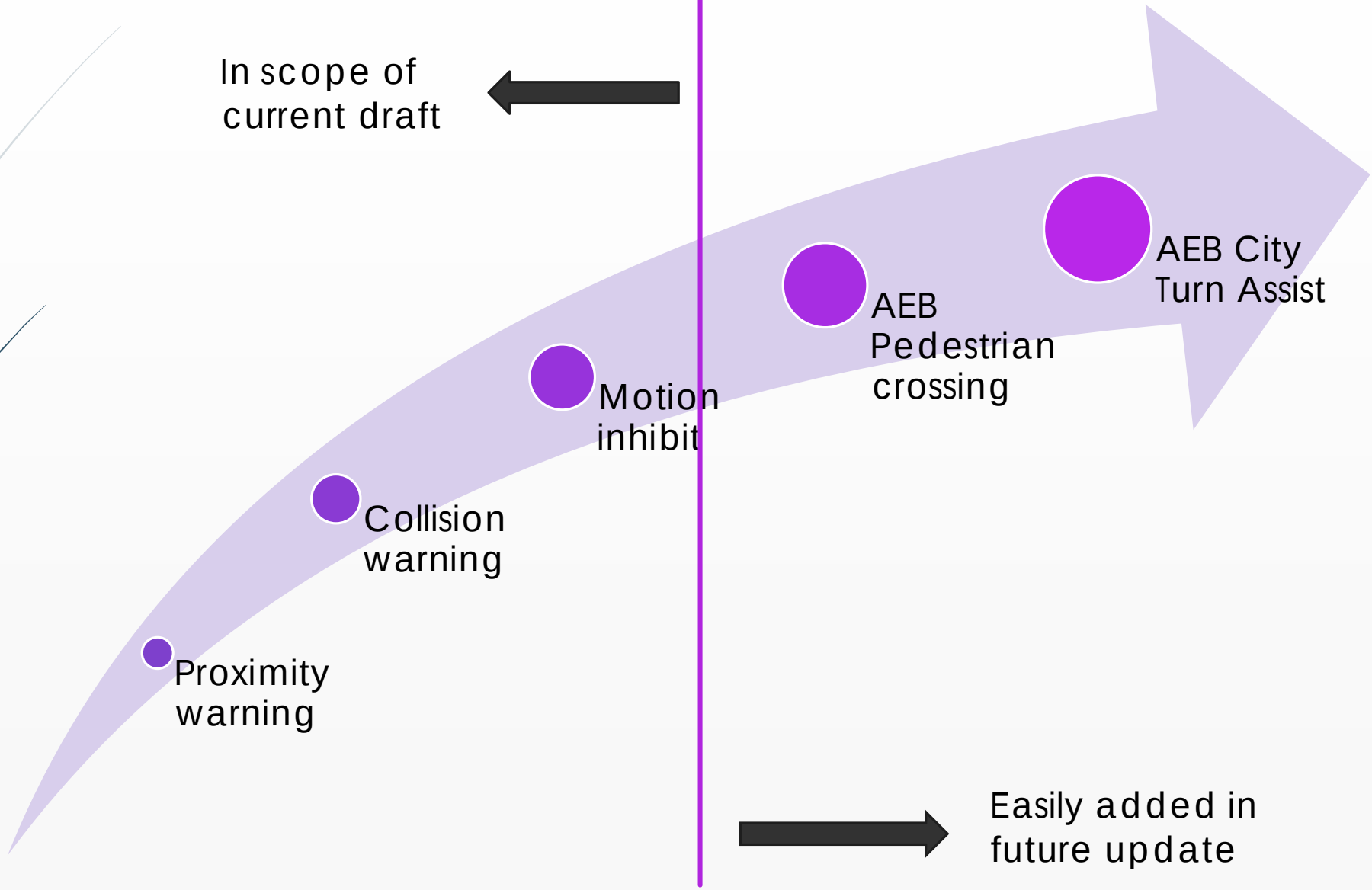
Scoring and weighting

Overall weighting	Crash frequency weighting	Test	Test weighting	Category	Category weighting	Weighted score														Importance of each test
						1	2	3	4	5	6	7	8	9	10	11	12	13	14	
90%	53%		55%	Performance	75%	0.05	0	0	0	0	0	0.05	0.1	0	0	0.05	0.2	0.2	0.2	**20%**
90%	53%	Moving Off Proximity	55%	HMI	25%	0.04	0.07	0	0	0	0	0.05	0.08	0	0	0.02	0.08	0.08	0.01	**7%**
90%	53%		45%	Performance	95%	0	0	0	0	0	0	0	0	0	0	0	0.03	0.2	0.2	**20%**
90%	53%	Moving Off Collision	45%	HMI	5%	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0	**1%**
90%	47%	Left Turn detect in	10%	Performance	75%	0	0	0.01	-0.01	0	0.03	0.01	0.03	0	0	0	0.03	0.03	0.03	**3%**
90%	47%	clutter	10%	HMI	25%	0	0	0	0	0	0.01	0	0.01	0	0	0	0.01	0.01	0	**1%**
90%	47%	Left Turn move off	30%	Performance	75%	0	0	0.01	0.01	0.02	0.05	0.01	0.05	0	0	0.02	0.05	0.05	0.05	**10%**
90%	47%	together	30%	HMI	25%	0	0	0	0	0	0.02	0.01	0.02	0	0.01	0	0.03	0.03	0	**3%**
90%	47%	Left Turn Pedal Cycle	40%	Performance	75%	0	0	0.02	0.02	0.03	0.06	0.02	0.06	0	0.06	0.03	0.13	0.13	0.13	**13%**
90%	47%	undertake	40%	HMI	25%	0	0	0	0	0	0.03	0.01	0.03	0	0.02	0	0.04	0.04	0	**4%**
90%	47%	Left Turn False Positive	10%	Performance	75%	0	0	0	-0.03	-0.03	0	0	0	0	0	-0.03	0	0	0	**3%**
90%	47%	No VRU	10%	HMI	25%	0	0	-0.01	-0.01	-0.01	0	-0	0	-0.01	-0.01	-0.01	0	0	-0.01	**1%**
90%	47%	Left Turn False Positive	10%	Performance	0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0%**
90%	47%	Straight	10%	HMI	100%	0	0	-0.04	-0.03	-0.04	0	-0.01	0	-0.04	-0.03	-0.03	0	0	-0.04	**4%**
5%		Quality, Durability		Performance	100%	0.01	0.01	0.02	0.02	0.03	0.05	0.04	0.04	0.05	0.05	0.05	0.04	0.05	0.03	**5%**
5%		Additional requirements		HMI	100%	0.01	0.01	0.01	0.01	0.01	0.05	0.01	0.01	0.05	0.01	0.03	0.05	0.05	0	**5%**
					total	**0.1**	**0.09**	**0.01**	**-0.01**	**0.01**	**0.3**	**0.18**	**0.44**	**0.04**	**0.12**	**0.13**	**0.7**	**0.89**	**0.6**	**100%**
					score %	**11%**	**10%**	**1%**	**-1%**	**1%**	**33%**	**20%**	**48%**	**5%**	**13%**	**15%**	**76%**	**97%**	**65%**	

Star rating	Rating boundaries	Nominal systems at each rating
0 Stars	≤10%	2, 3, 4, 5 and 9
1 Star	>10% and ≤30%	1, 7, 10, and 11
2 Stars	>30% and ≤50%	6 and 8
3 Stars	>50% and ≤70%	14
4 Stars	>70% and ≤90%	12
5 Stars	>90%	13

- Based mainly on hypothetical systems at this time (2 real systems)
- Distinguishes between current systems but assumes imminent market arrival of OEM systems with greater functions (e.g. Wabco/Mercedes)
- Challenging nature should be subject to review and benchmarking of available and near market systems

Roadmap of future technologies



Comparing proposals

Proposals are procedurally similar and much in common but....

TFL London

- Best practice rating covering aftermarket progressing to OEM
- Vehicle starting from rest, limited variation in pre-crash speed
- Low lateral separation (<1.5m)
- Discourage response to inanimate objects & VRUs stationary on kerb
- Encouraging best practice HMI/Warning

Bast Germany

- Regulatory Minimum standard for OEM fit
- Vehicle always moving, wider range of pre-crash speed
- High lateral separation (<4.5m)
- Prohibit response to stationary objects unless they are VRUs
- Little control on HMI/Warning

Conclusions

- **Experience with systems in London suggests**
  - High risk of ‘false positives’ with simple systems even when sensitive to only <1.5m lateral separation
    - Results in ignoring warnings and/or disabling system via vandalism if necessary
  - If systems are required to be sensitive to 4.5m lateral then in London they will detect inside shops in many cases!
  - To ensure effectiveness either or both of following may be required
    - Better avoidance of ‘false positive’ including stationary pedestrian on kerb
    - Correlation of warning urgency/intrusiveness with level of threat presented (e.g. amber visual proximity warning, red audio-visual collision warning
- **Need to ensure range of differential speeds and positions fully covers the ‘type 2 crash’ where HGV moves off from rest at lights while approached at speed from behind by pedal cycle**
- **In GB a significant minority of VRUs are killed in front of an HGV as it moves off from rest**
  - Approximately equal in scale to cyclists in turns (maybe not across all EU?)
  - Could scope be expanded to include a ‘moving off’ function?