AEBS-HDV IWG
Input from industry

AEBS-HDV-05

June 30 and July 1, 2021

Content

Open items

- Brake delay time (pneumatic braking)
- Time to 1g - LCV hydraulic
- City vs highway driving
- M2N2 derived from M1N1
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- Solo tractors
- New: speed range
- New: vehicle longitudinal centre planes (offset)

V2C

- Summary
- Follow shark fin curve up to 110

V2P

- Reminder of 04 meeting
- New: Another approach for V2P
- Summary

V2B

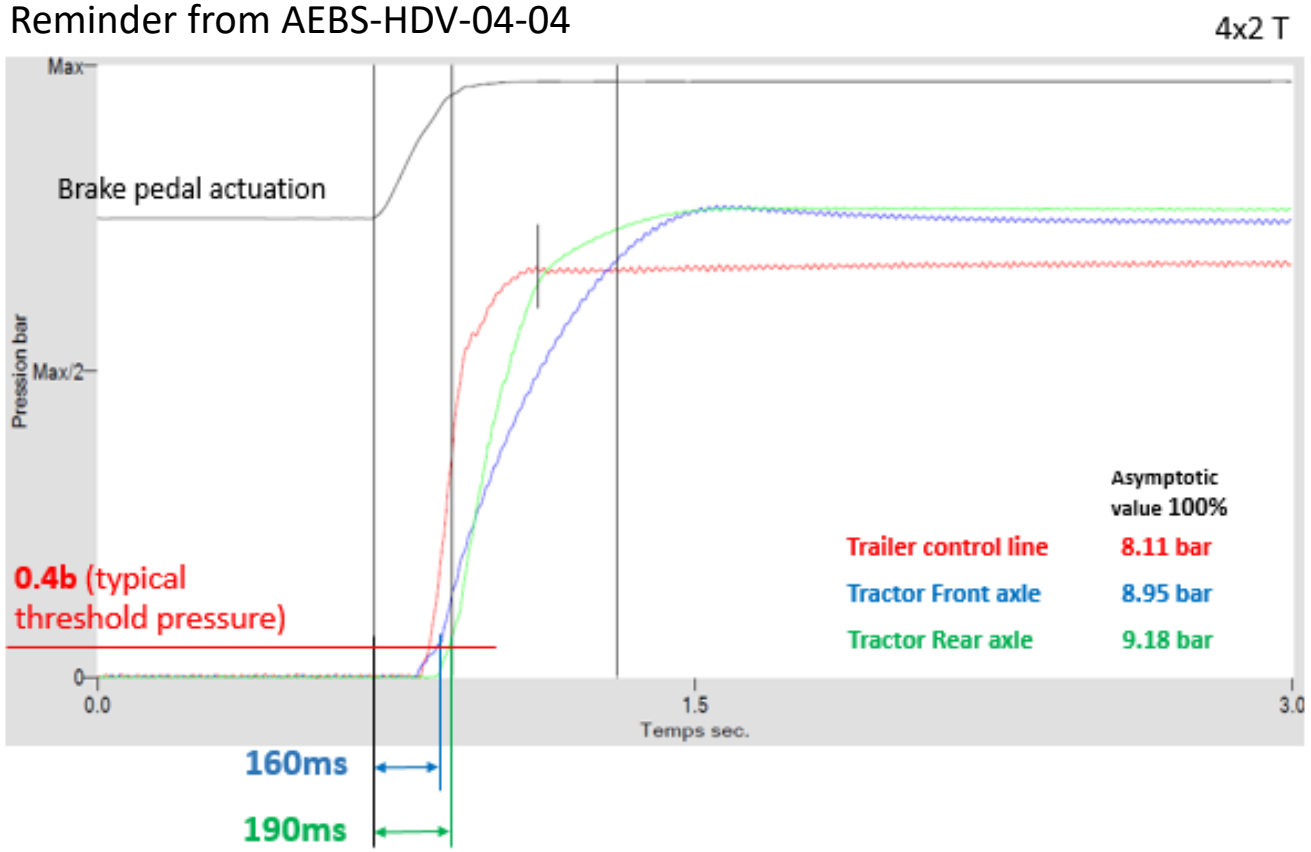
Backup slides

Open items

Brake delay time (pneumatic braking)
Reminder from AEBS-HDV-04-04

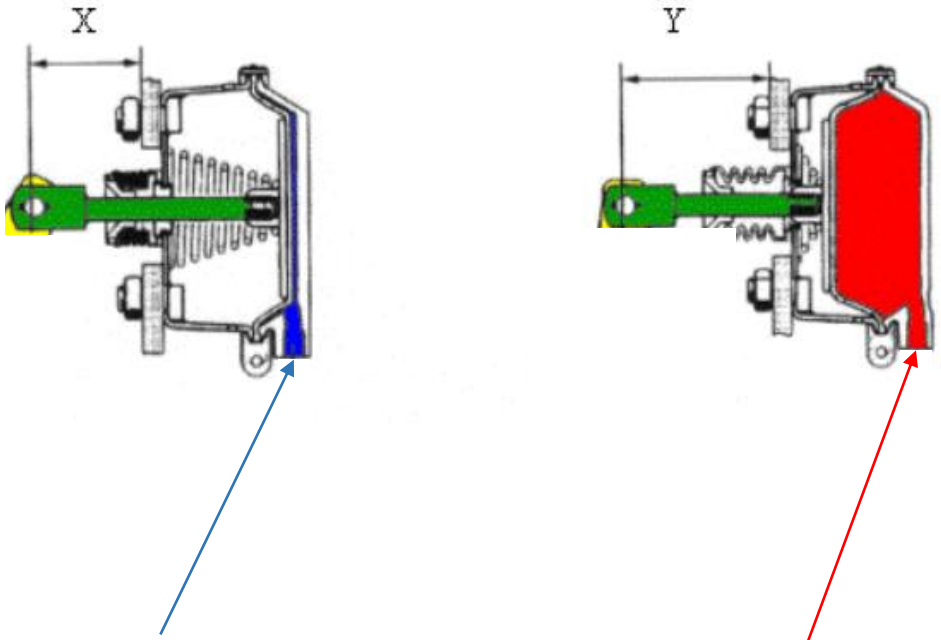
- AEBS M1N1 IWG took as an assumption that the time-to-1g (T1g) was applicable immediately once the brake demand starts
- This assumption is not realistic for HCVs due to the existence of an extra-delay time on pneumatic braking, compared to hydraulic braking:
  - Compressibility of air
  - Lower control pressure (10 bars pneumatic vs 150-200 bars hydraulic), leading to bigger actuators volume
- Assuming the same detection time, this pneumatic brake is adding on top.

Reminder from AEBS-HDV-04-04



Industry proposal for HDVs with pneumatic braking:
Assuming an absolute delay time of **150ms** is used in the calculation model, a T1g of **1s** can be considered as relevant.

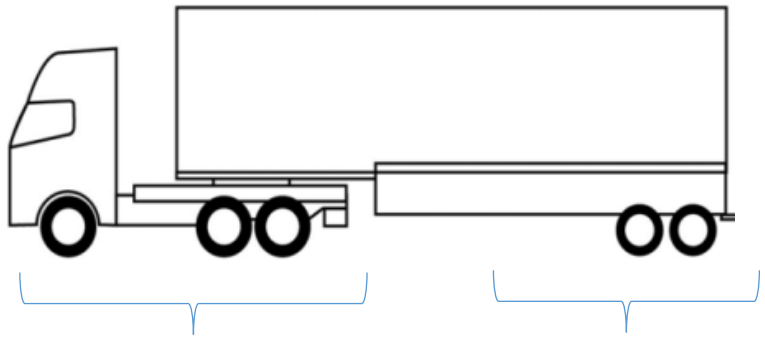
Brake delay time (pneumatic braki
Pre-filling of brakes



Pre-filling of the pipe between brake valve and cylinder would not reduce the delay significantly

Pre-filling of cylinder would create a risk that the pads leak the disc

→ this may create **functional safety issues**



Prefilled
(Short delay)

Not Prefilled
(long delay)

- **This typically creates a Jack-knifing risk**
- **Prefilling trailer brakes may solve this, but the truck cannot "blindly" pre-fill the trailer brakes (without knowing the threshold pressures of the actual trailer being towed)**

- **Industry does not look at brakes pre-filling as a potential solution**
- **The additional brake delay of pneumatic braking is there, and we have to account for it in the AEBS strategy, as proposed in AEBS-HDV-04-04**

Time to 1g – LCVs with hydraulic braking

M3 with hydraulic brake in Japan

- GVW 4.5～6t
- 21～29 passengers
- Examples of usage: hotel shuttle, nursery school bus

Time to 1g – LCVs with hydraulic braking

N2 with hydraulic brake in Japan

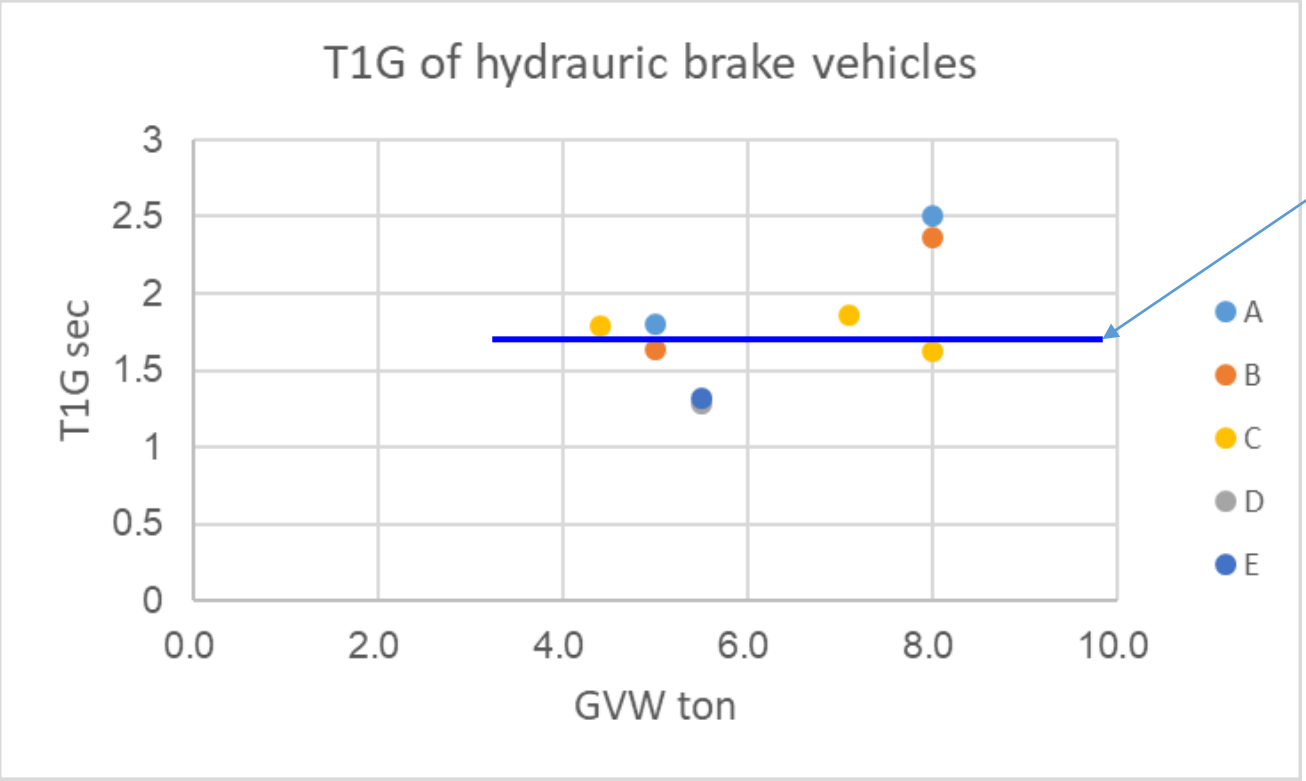
- GVW 4.5～8t
- Examples of usage: deliveries, construction,






Time to 1g – LCVs with hydraulic braking

New Data

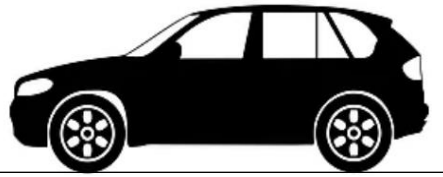


To get the average value, first the values of each OEM (A… E) were averaged, then the average of OEMs was calculated.

Industry compromise proposal

- Take an **average** of **1.7s**
- Keep same assumptions as in AEBS-HDV-04-04:
  - Deceleration of 6m/s²
  - LPS of 1.3s
- The avoidance speed becomes **35kph** (was **26.5kph** in AEBS-HDV-04-04)
- This value is consistent with N1 requirements in R152 series 01 (**38kph** for the N1 maximum mass)

City vs highway driving

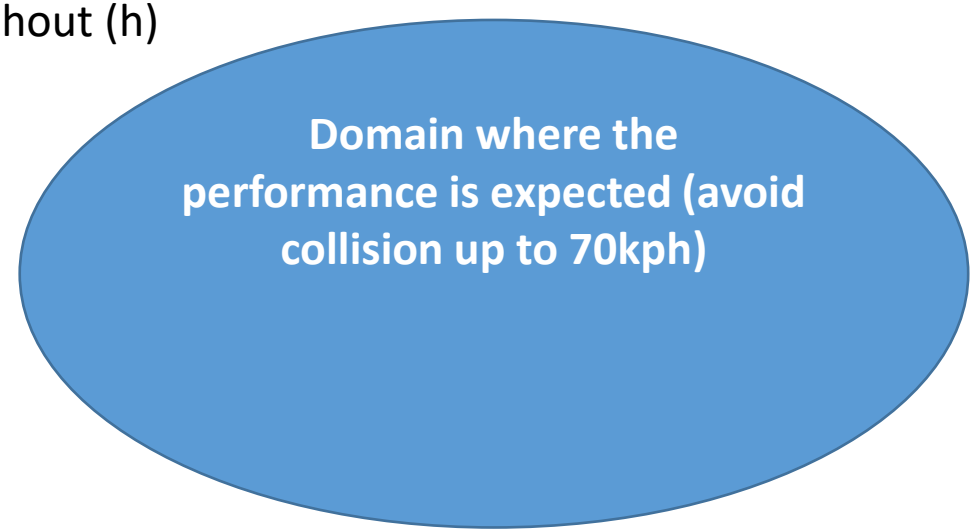


5.2.1.4. Speed reduction by braking demand

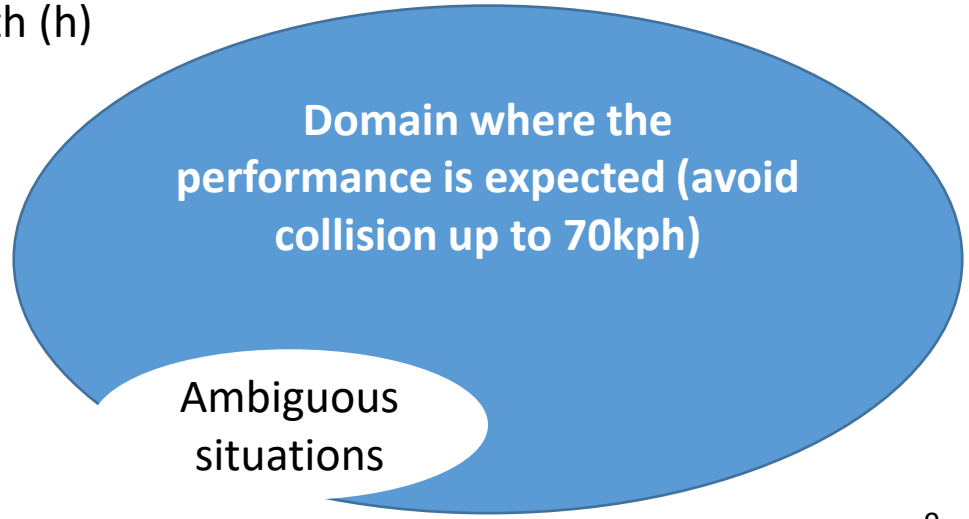
…

(h) In unambiguous situations (e.g. no motorcycle nor bicycle in between rows of vehicles, no laterally waving vehicle in the adjacent lanes)

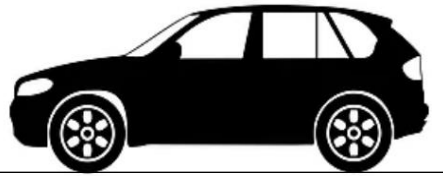
Without (h)



With (h)



City vs highway driving

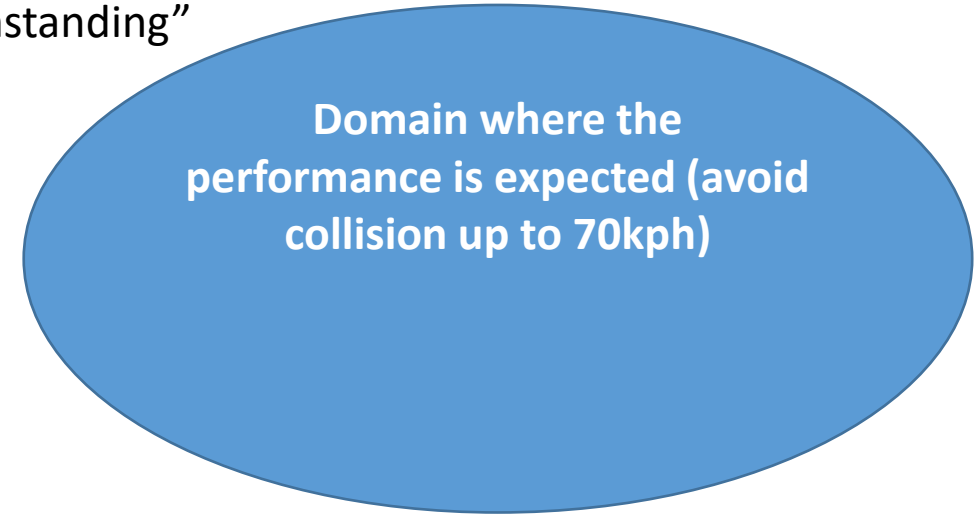


5.2.1.4. Speed reduction by braking demand

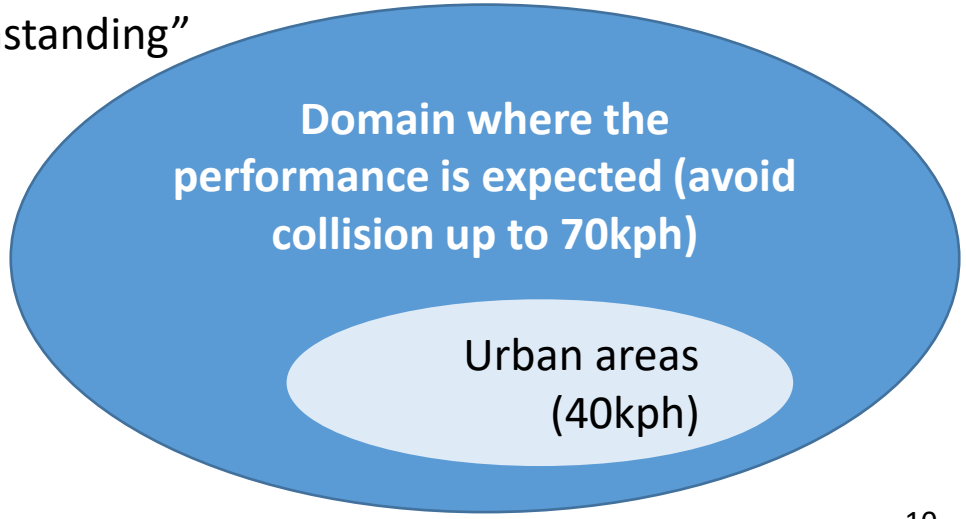
…

Notwithstanding the table above, for those vehicle able to detect urban areas where the speed is limited to 60kph or below, the speed reduction shall not be lower than 40 kph, for actual vehicle speed between 10 and 60kph. In this case, the means used by the vehicle to detect the urban areas as specified above shall be described by the vehicle manufacturer, and the safety concept assessed by the Technical Service according to Annex 3 of this regulation.

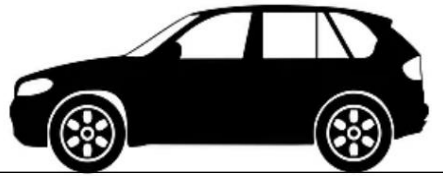
Without "notwithstanding"



With "notwithstanding"



City vs highway driving



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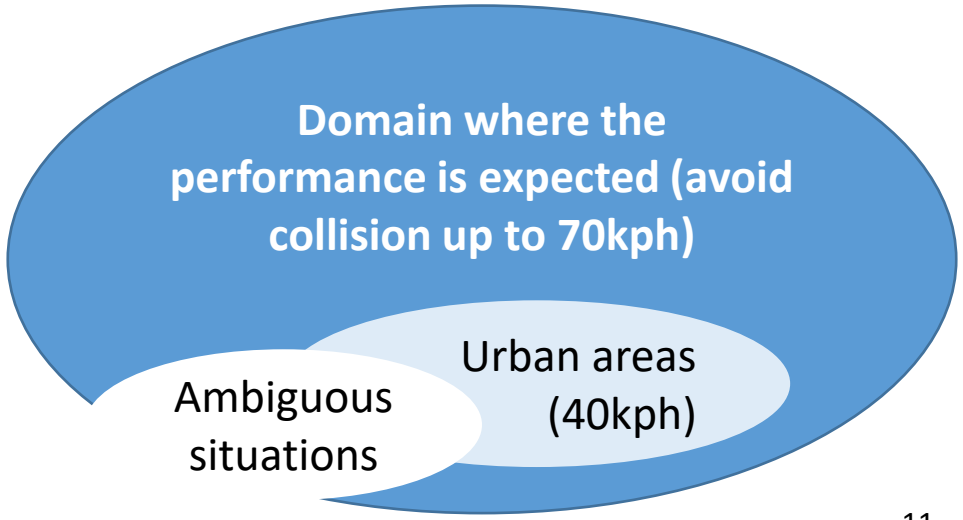
We need both…

With both (h) and "notwithstanding"



M2N2 derived from M1N1

HDV-04 outcome

- Agreement on the principle that M2N2 derived from M1N1 may be approved to either R131 or R152
- This option applies to V2C/P/B as a whole (no mix possible, e.g. V2C with R131 and V2P/B with R152)
- Industry homework: Provide discriminative criteria for identifying LCVs derived from M1N1

Industry input for HDV-05

Industry explored the opportunity to define technical criteria to differentiate 'M2N2 derived from M1N1' from other vehicles, and found out that it was **a dead-end**:

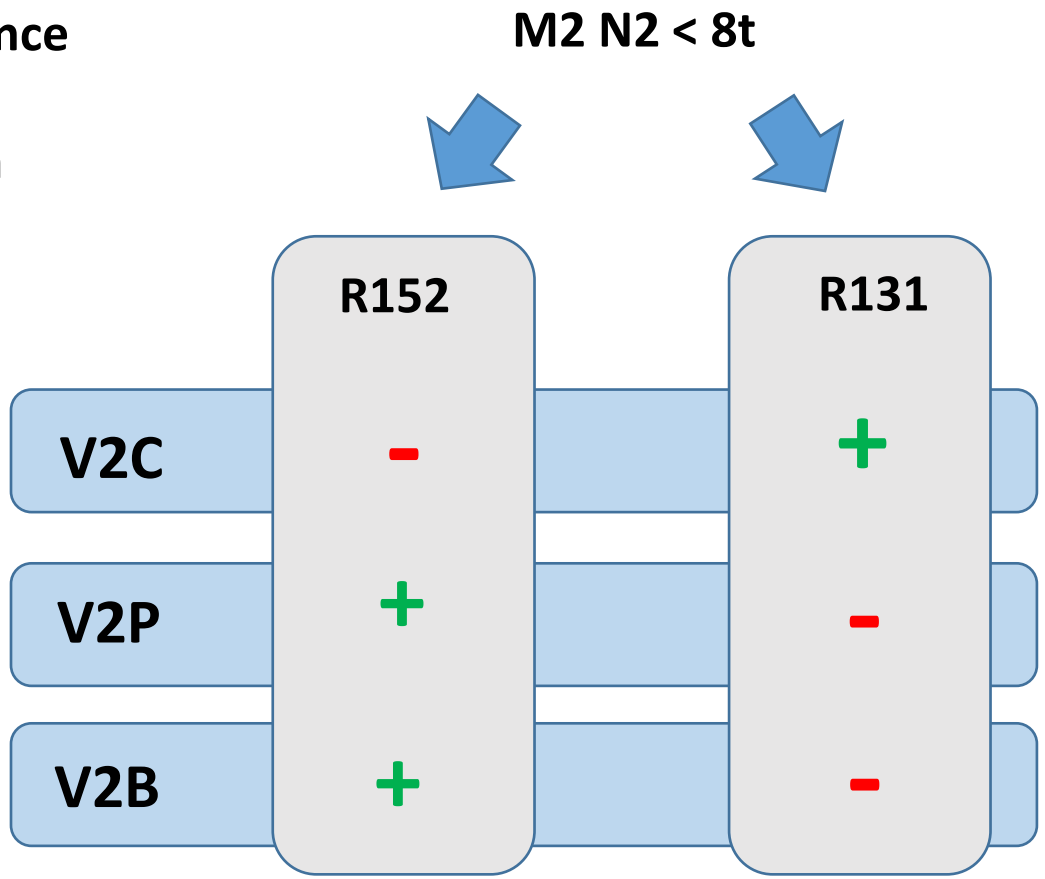
- Quite difficult to define specific technical criteria which would differentiate such vehicles
- The only criteria to select one or the other regulation should be technical (the vehicle dynamics, the braking capabilities etc.)
- This approach has a fundamental disadvantage: a M2N2 can only be approved to R152 if it is derived from an existing/approved M1N1…

Industry then explored **another alternative**:

- to provide the option to either use R131 or R152 to **all** M2 and N2<8t vehicles (possibly limited to hydraulic braking)
- Industry wondered **what could be the safety drawback**, and actually found **none** (see next slide)
- We thus **recommend** to follow that 2nd approach.

M2N2 derived from M1N1

What would be the safety drawback to give the option to either use R131 or R152 to all M2 and N2<8t vehicles?



This approach is the same as the one used for **N1 vehicles in R13 and R13H**.
What do we learn from this situation:

- The choice is left to the vehicle manufacturer, who knows what regulation best applies to its own vehicle, based on technical criteria. This leads to:
- N1s with a "M1 twin" follows R13H.
- N1s with a "heavier twin" follows R13.

Conclusions: using R152 is not safer than using R131 (and the other way round), just different / more adapted to the technical characteristics of the vehicle.

The vehicle manufacturer of M2 and N2<8t should be able to choose R152 or R131, the same way as for N1 with regard to R13 / R13H.

M2N2 derived from M1N1 - Proposal

Proposal to amend UN R131:

Add a footnote to scope:

***/ For vehicles of category M2 and for N2 with a maximum weight below or equal to 8t, Contracting Parties that are signatories to both Regulation No. 152 and this Regulation shall recognize approvals to either Regulation as equally valid.**

(same wording as for N1 in UN R13 and R13H)

Proposal to amend UN R152 :

1. Scope

This Regulation applies to the approval of vehicles of Category M1 and N1 ***** with regard to an on-board system to

a. Avoid or mitigate the severity of a rear-end in lane collision with a passenger car,

b. Avoid or mitigate the severity of an impact with a pedestrian.

Footnote */ This Regulation offers an alternative set of requirements for Category M2 and for N2 with a maximum weight below or equal to 8t to those contained in UN Regulation No. 131. Contracting Parties that are signatories to both Regulation No. 131 and this Regulation shall recognize approvals to either Regulation as equally valid.

5.2. Specific Requirements

For vehicles of category M2 and N2 covered in the scope of this regulation, the requirements of category M1 and N1 (respectively) shall apply.

Solo tractors

2.20 **"Situations where the deceleration is limited in empty conditions" are situations where the vehicle's brake system limits the deceleration value in order to prevent a rear axis lift-off, such as braking with certain short-wheelbase solo tractor vehicles. ~~This shall be demonstrated to the satisfaction of the type approval authority.~~**

		typical values	with min added load on RA 480 kg	with Max added load on RA 820 kg
Wr	(t)	1,8	2,28	2,62
W	(t)	7	7	7
L	(m)	3,6	3,6	3,6
H	(m)	0,9	0,9	0,9
Alpha		**1,0**	**1,30**	**1,50**

5.1.8. **In situations where the deceleration is limited in empty load conditions, and provided this would be demonstrated by the vehicle manufacturer to the technical services, the requirements applicable to the vehicle with a mass in running order in the tables of paragraphs 5.2.1.4., 5.2.2.4. and 5.2.3.4. shall be deemed fulfilled if the impact speed requirements are met with an added mass on the rear axle, calculated to implement an α value equal to 1.3 [+0.2 / -0.0],**

with $\alpha = W_r/W \times L/H$, where :

a) W_r is the rear axle load.

b) W is the subject vehicle mass in running order.

c) L is the subject vehicle wheelbase.

d) H is the subject vehicle centre of gravity height in running order.

[Additionally, the relative impact speed shall be measured with a vehicle mass in running order, and the result appended to the test report.]

Speed range

***/ Typical use of LCVs is short distance, urban; unlike HCVs, more focused on long haulage**
→Proposal to use same speed range as for R152 (with regard to performance)
→System activation range can be kept with 10-100 (M) and 10-90 (N).

V2C 	R152	R131	
	M1, N1	LCV *	HCV
System activation	At least 10 - 60	At least 10 – 100 (M) 10 - 90 (N)	At least 10 – 100 (M) 10 - 90 (N)
Performance requirements	10 - 60	10 – 100 (M) 10 - 90 (N) **→ 10 – 60**	10 – 90 (N) 10 – 100 (M)
(current R131) System activation		At least 15 – maximum design speed	At least 15 – maximum design speed
Performance requirements		At 80	At 80

V2P 	R152	R131	
	M1, N1	LCV	HCV
System activation	At least 20 - 60	At least 20 - 60	At least 20 - 60
Performance requirements	20 - 60	20 - 60	20 - 60

Vehicle longitudinal centre planes (offset)

(d) In situations where the vehicle longitudinal centre planes are displaced by not more than 0.2 m;

It may be understood that each centre plane (the one of the target vehicle and the one of the subject) should be displaced (in opposite directions, that would mean +/-0.4m)

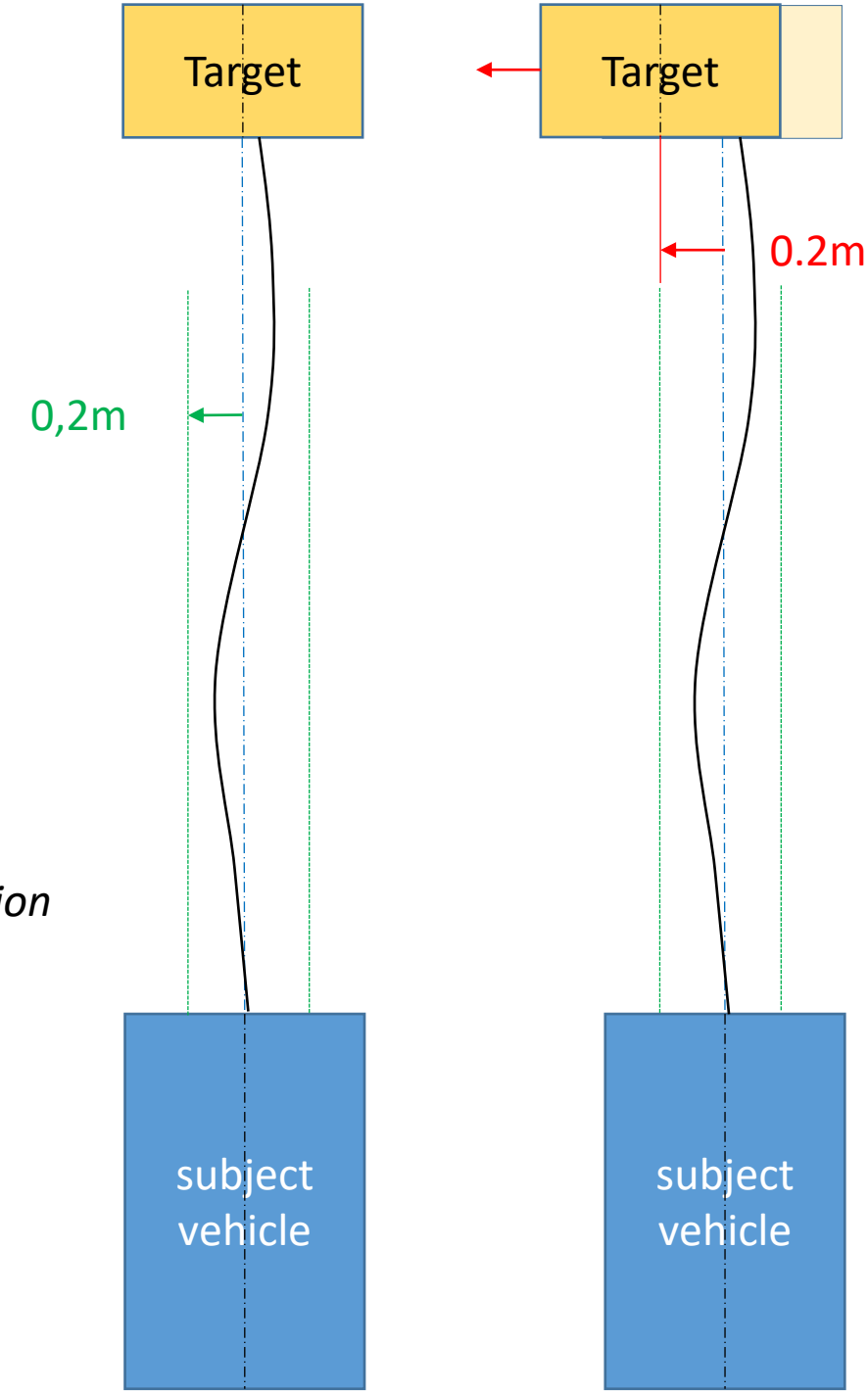
Requirement section:

(d) In situations where the **target** ~~vehicle~~ longitudinal centre plane~~s~~ ~~are~~ **is** displaced by not more than 0.2 m **compared to the subject vehicle longitudinal center plane**;

Test section:

6.5 The subject vehicle and the moving target shall travel in a straight line, in the same direction, for at least two seconds prior to the functional part of the test. with a subject vehicle to target centreline offset of not more than 0.2m.

Interpretation



Vehicle longitudinal centre planes (offset)

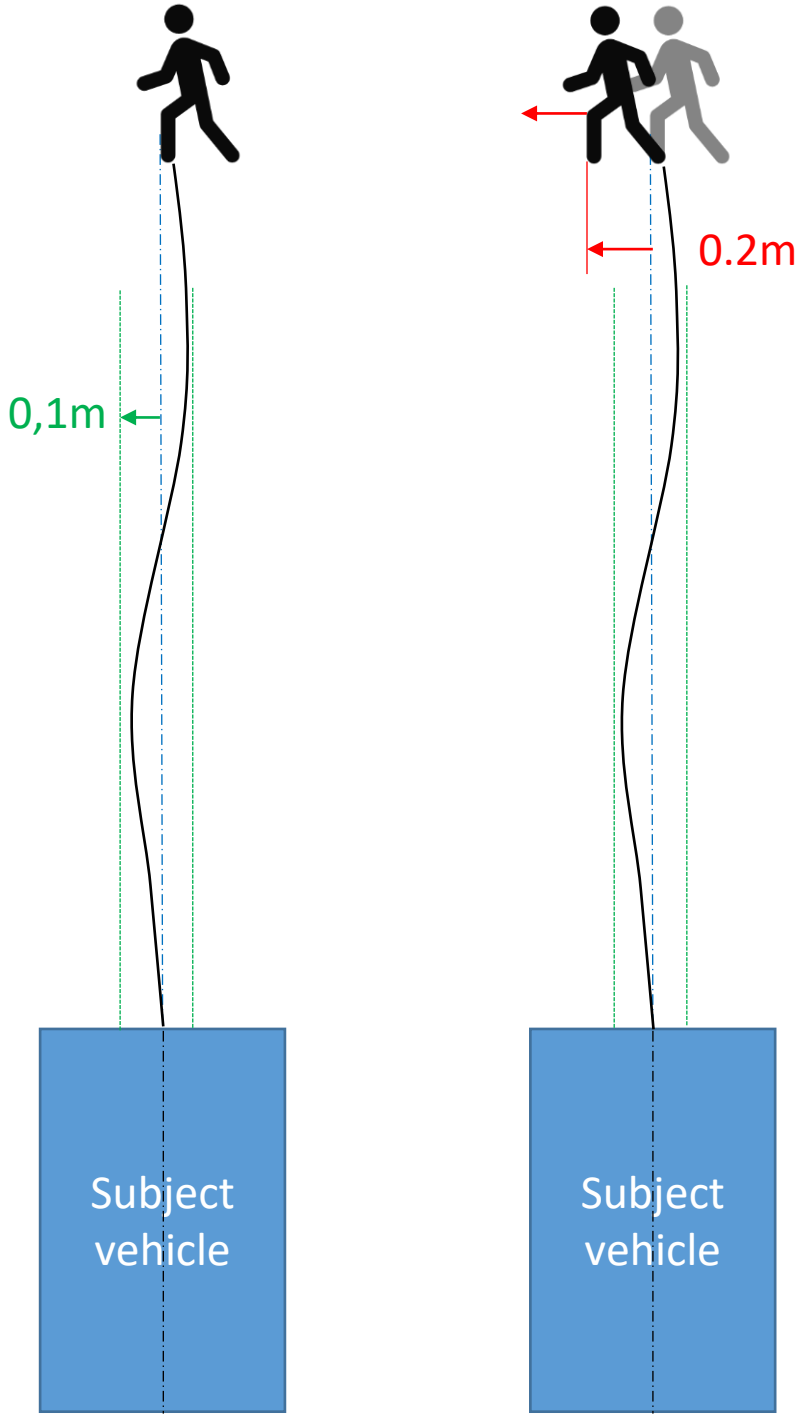
Requirement section:

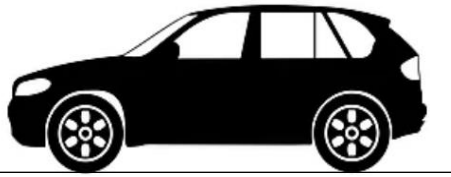
(e) In situations where the anticipated impact point is displaced by not more than 0.2 m compared to the vehicle longitudinal centre plane;

Test section:

6.6.1. The subject vehicle shall approach the impact point with the pedestrian target in a straight line for at least two seconds prior to the functional part of the test with an anticipated subject vehicle to impact point centreline offset of not more than 0.1 m.

Interpretation

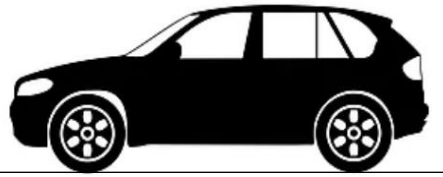




V2C

Summary (V2C) Peak avoidance speed in relative speed situation – for all load conditions*

*requirements to be eased for those facing difficulties in empty conditions (solo tractors)

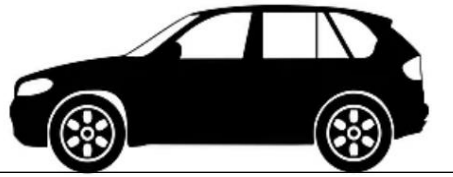


Extract from AEBS-HDV-04-06-Rev.1

Updated for AEBS-HDV-05

Vehicle category			CLEPA/OICA	D	AEBS-HDV-04	
M2 **N2 < 8t**	derived from M1N1	Hydraulic braking	**50 km/h**	**40**	**50** (R152 as alternative)	**R152 as alternative**
	derived from / based on "heavies"	Hydraulic braking **(including M3)**	~~**26.5 km/h**~~ **35 km/h**	**40**	**Industry compromise proposal (based on slide "T1g – LCV") Reduce speed range to 10-60km/h**	
		Pneumatic braking	**68 km/h** (highway) **40 km/h** (city)	**40**	**68 km/h** (highway) **40 km/h** (city)	
N2 > 8t **M3** (except hydraulic braking) **N3**			**68 km/h** (highway) **40 km/h** (city)	**70**	**[70] km/h** (highway) **40 km/h** (city)*	*CLEPA/OICA to propose a definition of "city" inspired from R152

Follow shark fin curve up to 110



5.2.1.1. Collision warning

When a collision with a preceding vehicle of Category M1, in the same lane with a relative speed above that speed up to which the subject vehicle is able to avoid the collision, is imminent, a collision warning shall be provided as specified in paragraph 5.5.1., and shall be triggered at the latest [1.4] seconds before the start of emergency braking.

AEBS Performance Calculation Tool

Maximum Deceleration [m/s²]	**6**
Time-To-1g [s]	**1**
TTC_{Brake} [s]	**1,9**

Peak Avoidance [km/h]	**69,5**

Test Speed [km/h]	Speed Reduction [km/h]	Impact Speed [km/h]
10	10,00	0,00
...	...	...
60	60,00	0,00
70	63,92	6,08
80	50,74	29,26
90	46,85	43,15
100	44,48	55,52
110	42,97	67,03

Data

- The system shall warn 1.4s ahead of the collision
- The system shall brake 1.9s ahead of the collision
- Design margin 0.2 / 0.3s

- Total: **3.6s**

Calculation

- At 110kph, a sensor range of **110m** is required

Follow shark fin curve up to 110

Data:

Motorway E11 / A75, Speed limit 110kph.

Required sensor range (to warn and brake in time): 110m.

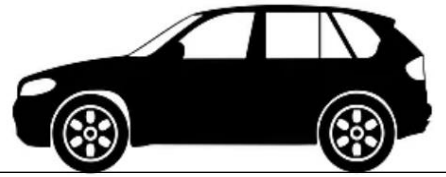
Scale : 110 m

200 m

At such speed and distance, there is a risk to for example detect a vehicle on the hard shoulder as being on the ego lane.

Recommendation to limit the requirements at 100kph.

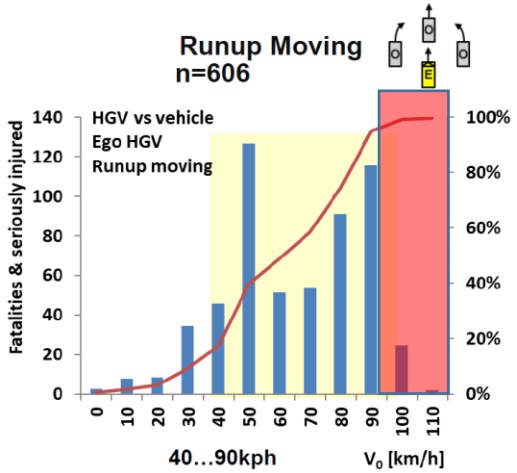
Follow shark fin curve up to 110

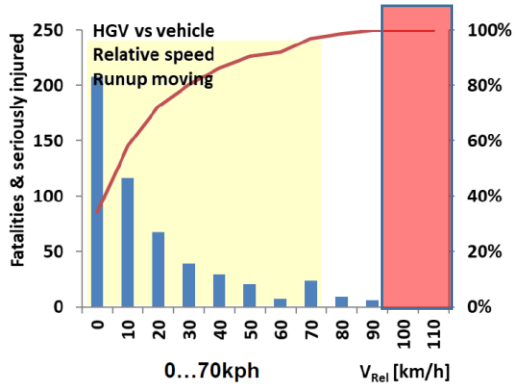


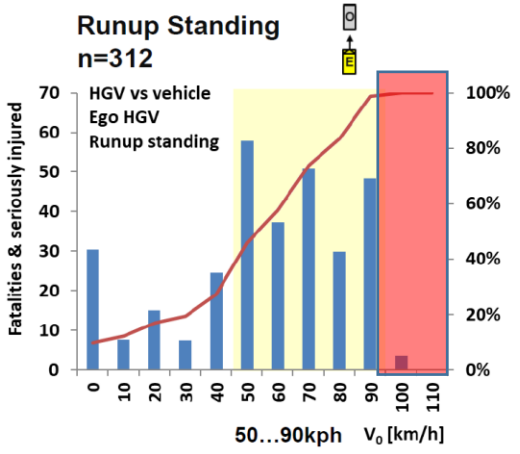
HGV vs Vehicle

HGV causing accidents with other vehicles

Ego







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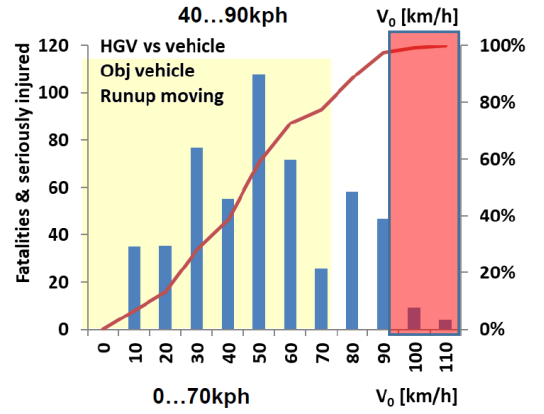
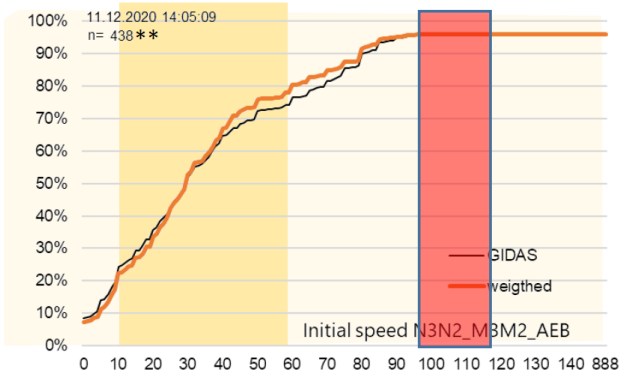


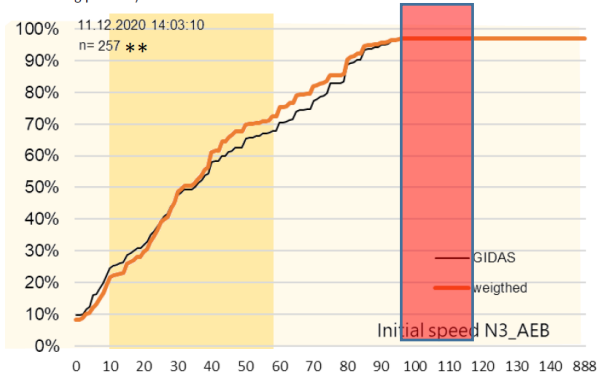
N3/N2 and M3/M2

** For overall evaluation, additional parameters are considered, Vehicles per accident (double counting possible) number of evaluable vehicles can be different



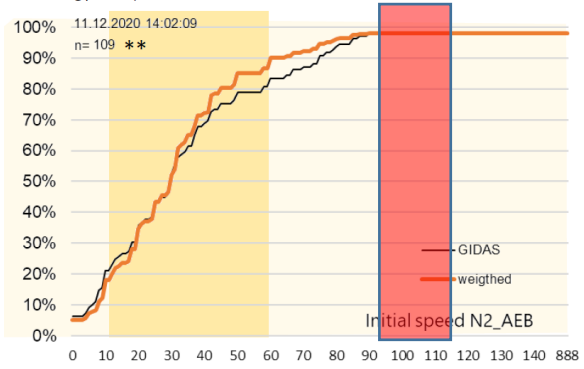
N3

** For overall evaluation, additional parameters are considered, Vehicles per accident (double counting possible) number of evaluable vehicles can be different



N2

** For overall evaluation, additional parameters are considered, Vehicles per accident (double counting possible) number of evaluable vehicles can be different



M3

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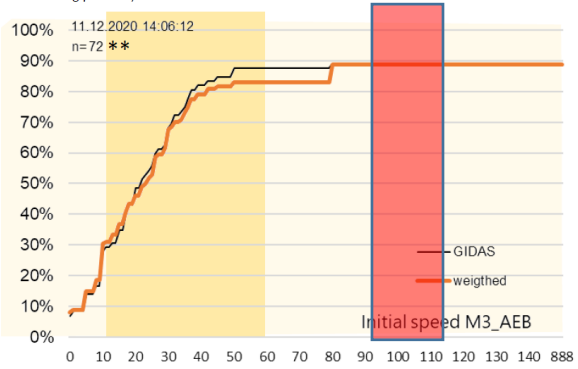
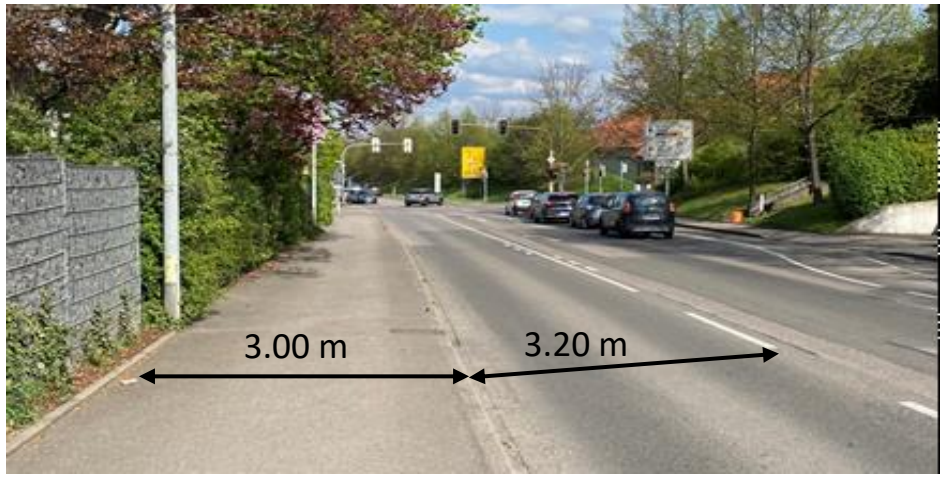


Based on the accident analysis (AEBS-HDV-SP-02-05) there is no need to enlarge the speed range mandatory to 110 kph
=> Keep current draft AEBS-HDV-04-08 as it is (100 kph)

V2P

Safety zone for HDVs in „real life“ conditions

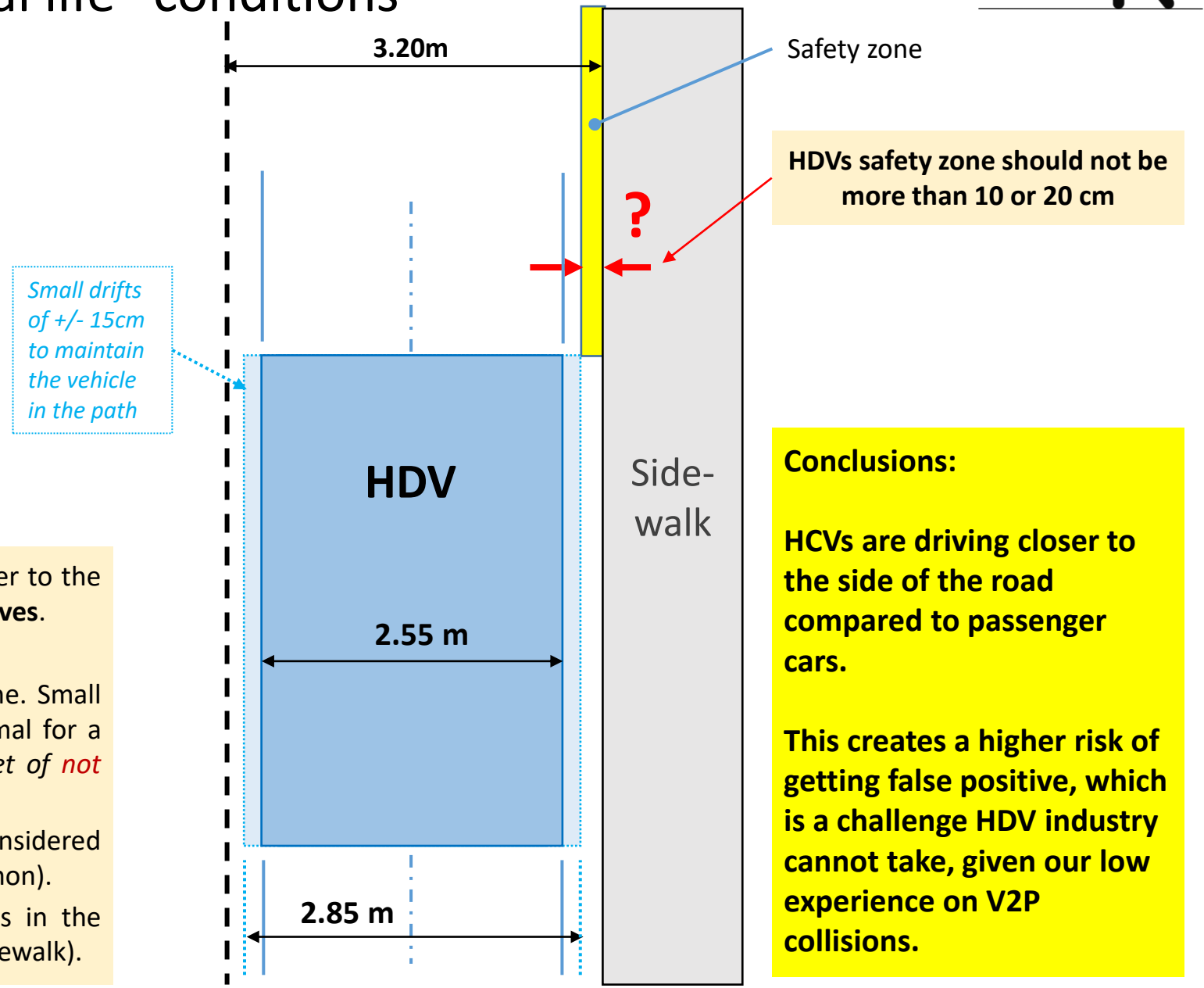
In general, it should be avoided to brake on pedestrian on the sidewalk (to limit the risks of false positive).



- HDVs are wider than passenger cars, thus are driving closer to the sidewalk, which is **increasing the risk of getting false positives**.

Additionnaly:

- A vehicle cannot be driven 100% in the center of the lane. Small drifts with e.g. **+/- 15cm or 20cm** to both sides are normal for a HDV. (Reminder: R131 specifies a *„target centreline offset of not more than **0.5 m**“*, in test section 6.4.1).
- Lanes in urban areas are often narrower than the 3.5m considered during the M1N1 discussions (3m or 3.30m are more common).
- A lot of roads in urban areas don‘t have lane markings in the middle (leading to some tendency to drive closer to the sidewalk).



Conclusions:

HCVs are driving closer to the side of the road compared to passenger cars.

This creates a higher risk of getting false positive, which is a challenge HDV industry cannot take, given our low experience on V2P collisions.

Proposed approach for HDVs

- Whereas:
  - HDV Industry has little experience on VRU and city-AEB;
  - Very few systems are available on the market, e.g. to support IWG discussions with actual measurements (as during the AEBS M1N1 IWG);
  - Available systems does not provide a comparable performance with those of the passenger cars available on the market.
  - **State of the art on one EU vehicle: 20kph collision avoidance**
- Industry proposes to define HDVs requirements **on the base of R152 step 1, and to value the state of the art measurements**.
- The values could be reviewed once practical experience will be available.

Updated for AEBS-HDV-05

LCVs and HCVs – Peak avoidance - Calculations

	M1N1 (step 1)	LCVs (M2 and N2<8t)			HCVs (N2>8t M3 N3)			
		derived from M1N1	derived from / based on "heavies"		4x2T N3		Multi-axles, construction…	
	Hydraulic braking	Hydraulic braking	Hydraulic braking	Pneumatic braking	Pneumatic braking		Pneumatic braking	
Vehicle width (m)	2	2	2	2	2.55		2.55	
TTC (s)	**0.72**	**0.72**	**0.72**	0.72	0.92		0.92	
TTC - 0.15s *	-	-	-	**0.57**	**0.77**		**0.77**	
Decel (m/s²)	9	7	6	6	7 (laden)	5.5 (solo)	6 (disc)	5.5 (drum)
T1g (s)	0.6	0.6	2.5 → **1.7s**	1	1	1	1	1
Peak avoidance (km/h)	**30**	**26**	6 → **12**	**12.5**	**22.5**	**20**	**21**	**20**
			This column also applies to M3 with hydraulic braking		"Special case" for solo 4x2 tractors		This column does not apply to M3 with hydraulic braking	
		R152 as an Alternative (to the choice of the vehicle manufacturer)						

Summary (V2P) Peak avoidance speed in relative speed situation – for all load conditions*

*requirements to be eased for those facing difficulties in empty conditions (solo tractors)

Vehicle category			CLEPA/OICA	D	J	
M2 N2 < 8t	derived from M1N1	Hydraulic braking	**26 km/h**	**20**	**[20]**	
	derived from / based on "heavies"	Hydraulic braking **(including M3)**	**~~6 km/h~~ → 12 km/h**	**20**	**[20]**	
		Pneumatic braking	**12.5 km/h**	**20**	**[20]**	
N2 > 8t **M3** (except hydraulic braking) **N3**			**20 → 22.5 km/h**	**20**	**[30]**	

Proposed approach for HDVs - summary

General approach

- Whereas:
  - HDV Industry has little experience on VRU and city-AEB;
  - Very few systems are available on the market, e.g. to support IWG discussions with actual measurements (as during the AEBS M1N1 IWG);
  - Available systems does not provide a comparable performance with those of the passenger cars available on the market.
  - **State of the art on one EU vehicle: 20kph collision avoidance**

- Industry proposes to define HDVs requirements **on the base of R152 step 1,**
  and to value the state of the art measurements.

- The values could be reviewed once practical experience will be available.

Technical principles

- In order to keep the risk of false positive **identical** to those of M1N1s, HDVs shall **not** be expected to start braking earlier than M1N1s.

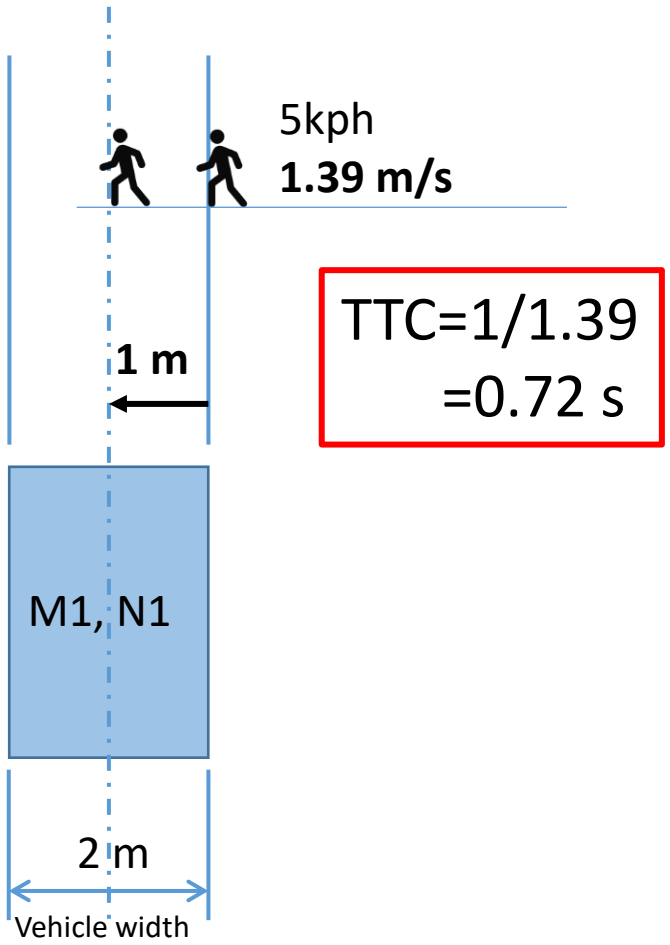
  Even with such an assumption, the challenge is already higher for HDVs compared to M1N1s:
  - Due to a bigger width, the position of the pedestrian when emergency braking must start is “shifted to the side” (on the sidewalk)
  - The effect of chassis-cab relative movement is unknown.

- The safety zone (defined as the distance needed for a pedestrian to stop at 5kph) is **independent** from the ego vehicle. No vehicle should be expected to start braking before the pedestrian enters that “safety zone”.

- Last but not least, the **lower** braking performance of HDVs vs M1N1’s shall be taken into account in the calculation of the required AEBS performance.

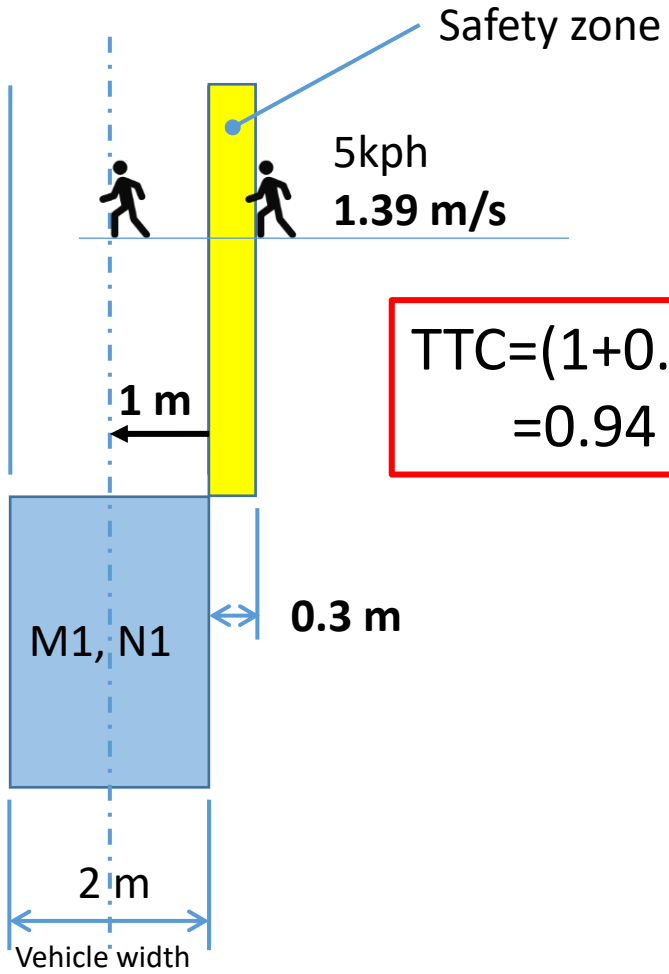
V2P braking time logic in R152

Step 1
00 series



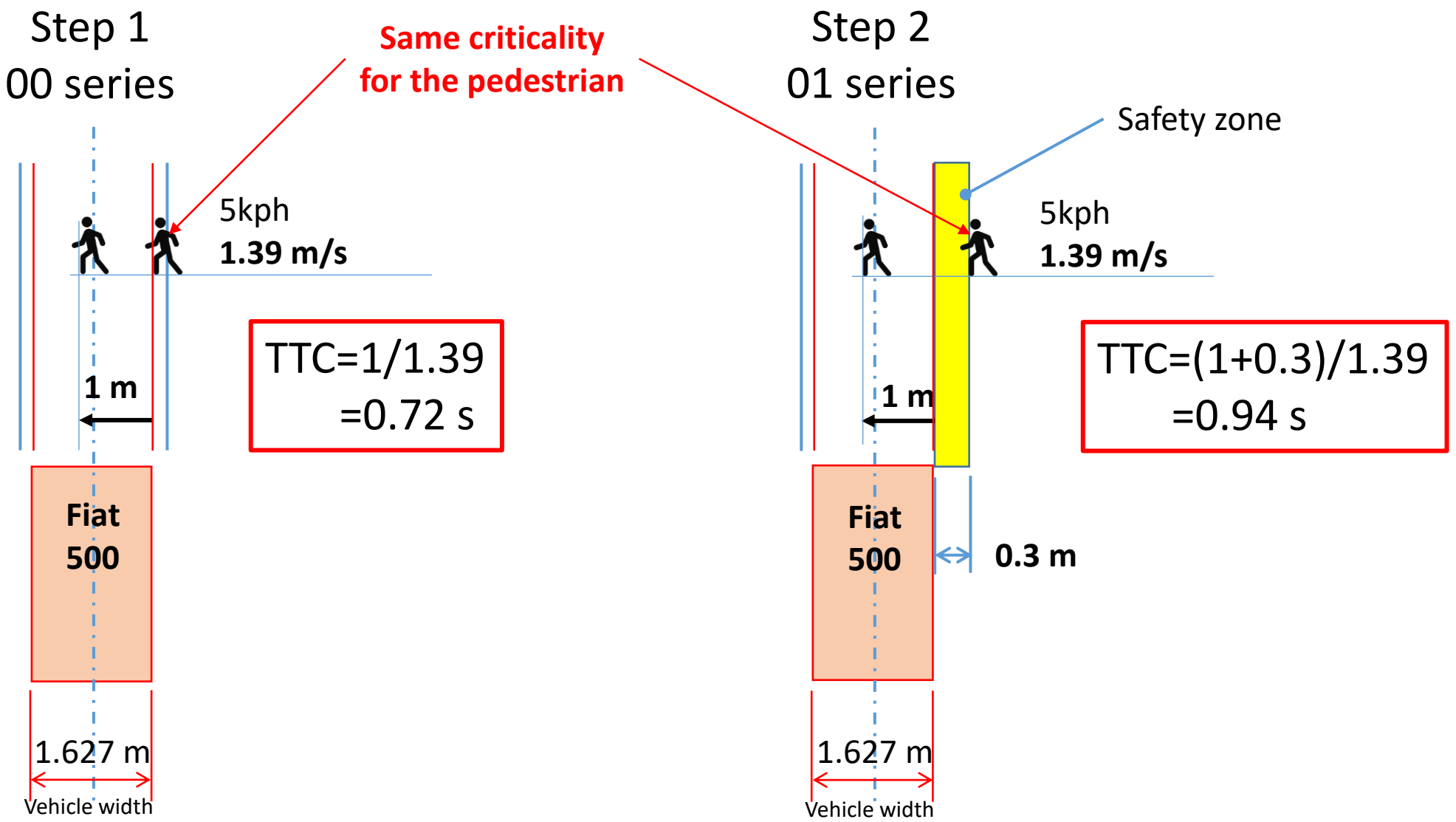
TTC=1/1.39
=0.72 s

Step 2
01 series

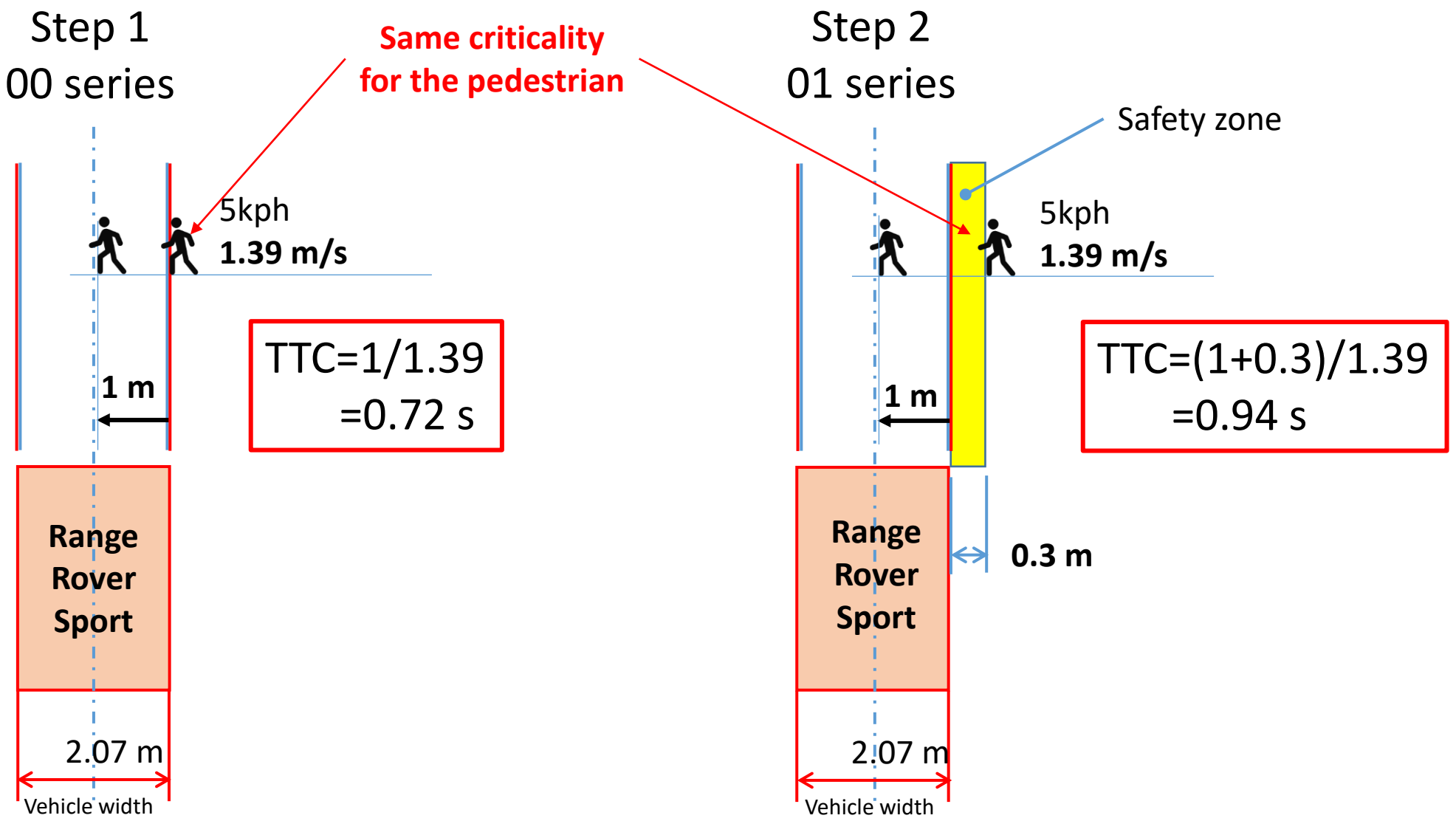


TTC=(1+0.3)/1.39
=0.94 s

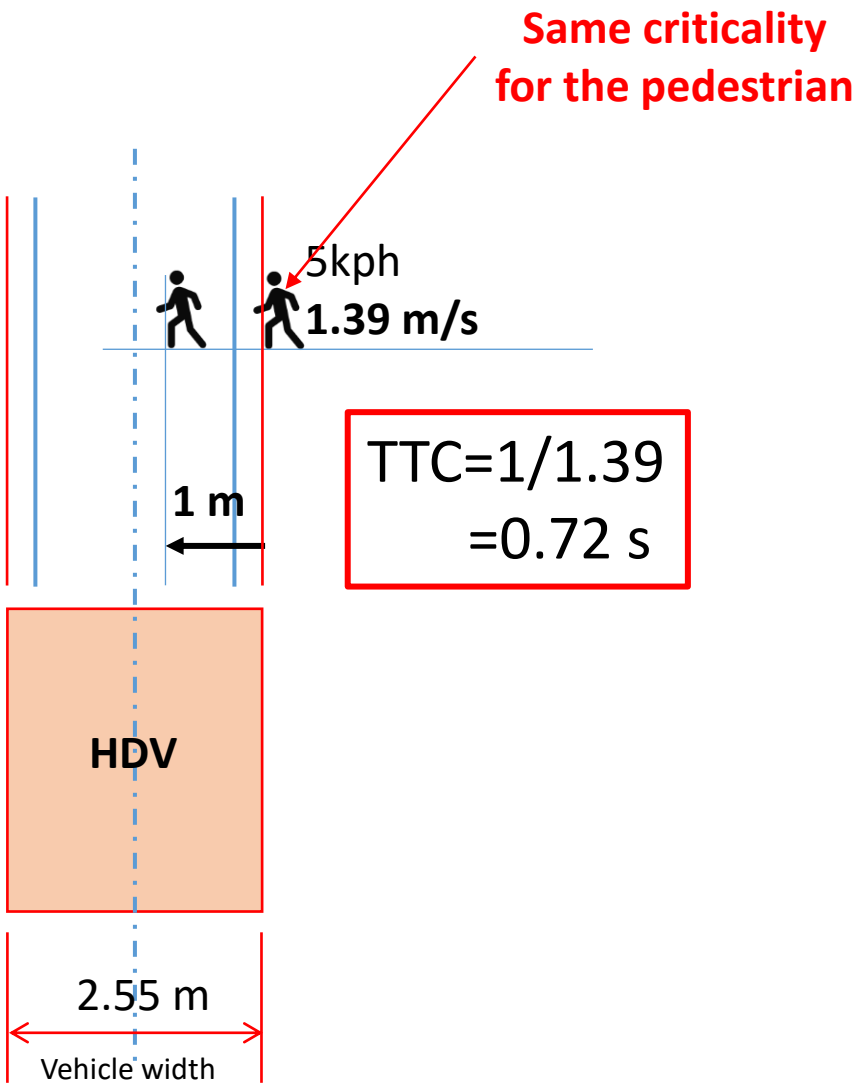
V2P braking time logic applied to a Fiat 500



V2P braking time logic applied to a Range Rover Sport



V2P braking time logic applied to a HDV



Summary

- Adopt the principle of an “ISO-criticality” for the pedestrian to HDVs
  (No intention to change R152 principles)
- Calculations

- Decel	6m/s²	7m/s²
- T1g	1s	1s
- TTC	0.72s	0.72s
- **Peak avoidance speed**	**19 kph**	**20 kph**

- **Conclusion:**

  Both approaches are consistent with a peak avoidance speed **around 20kph**, which also reflects the state-of-the-art (of one OEM)

V2B

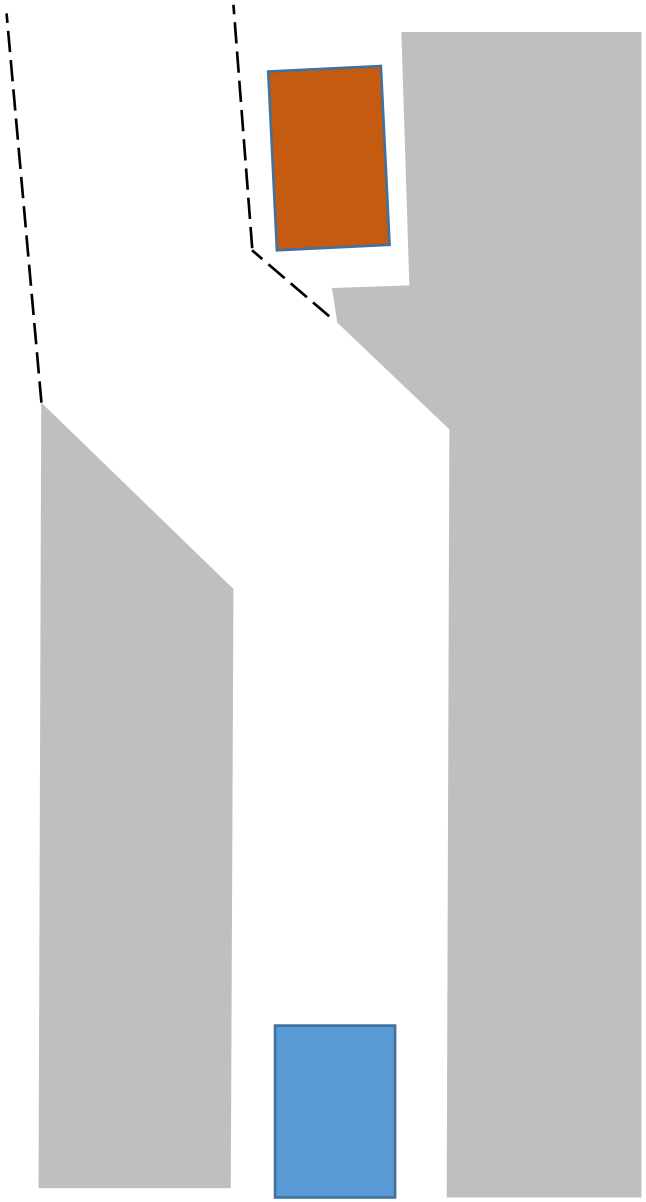
Proposed approach for HDVs

Industry is not in a position to make a proposal for this session of the IWG, thus suggests focusing the efforts on V2C and V2P for the time being.

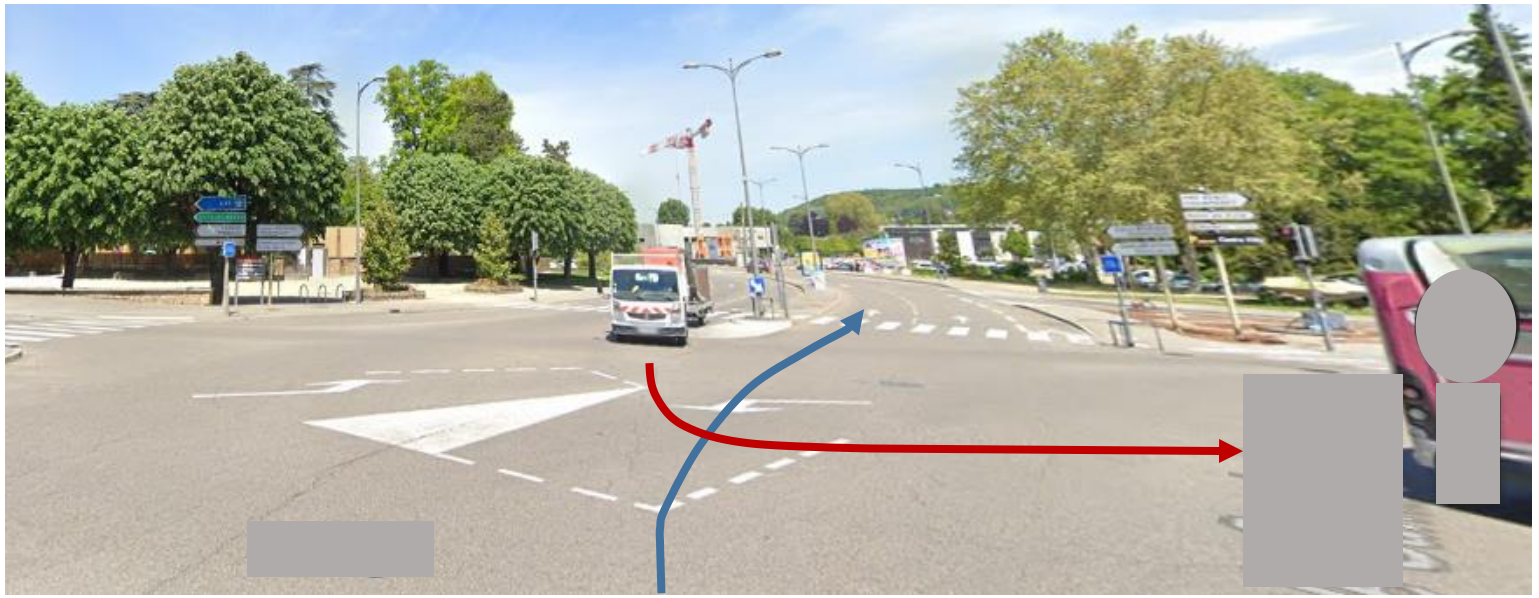
Back-up slides

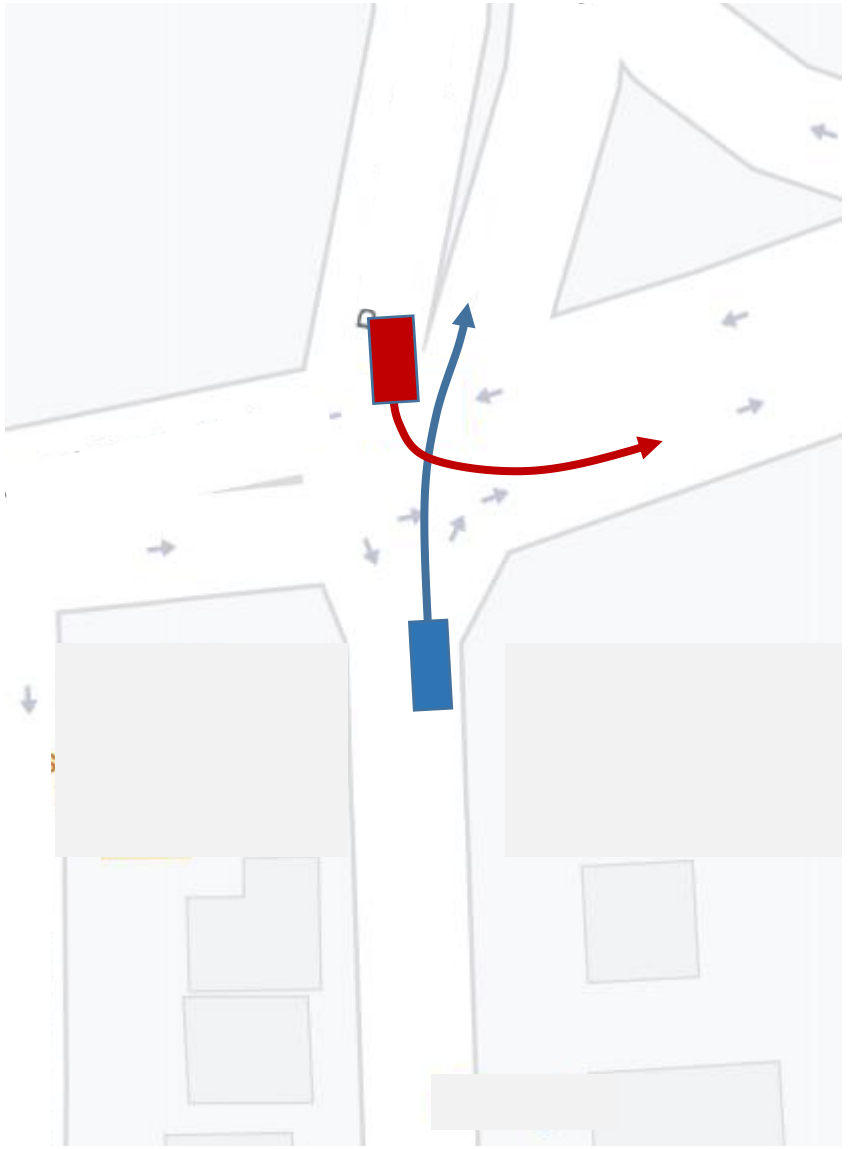
City vs highway driving - Ambiguous situations

Picture from AEBS camera



City vs highway driving - Ambiguous situations





City vs highway driving - Ambiguous situations

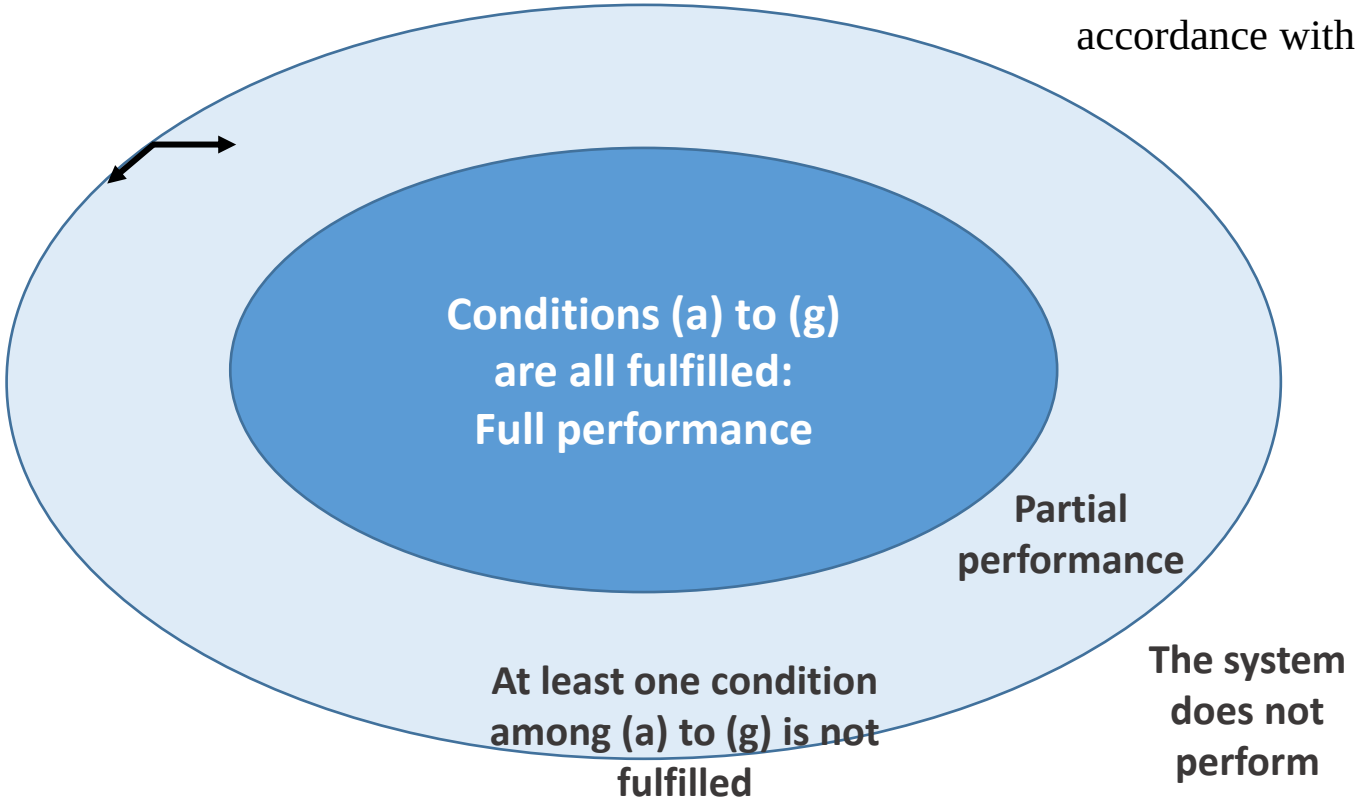
“it is also recognized…”

5.2.1.4. Speed reduction by braking demand

...the AEBS shall be able to achieve a relative impact speed… as shown in the following tables :

(a)… (g)…

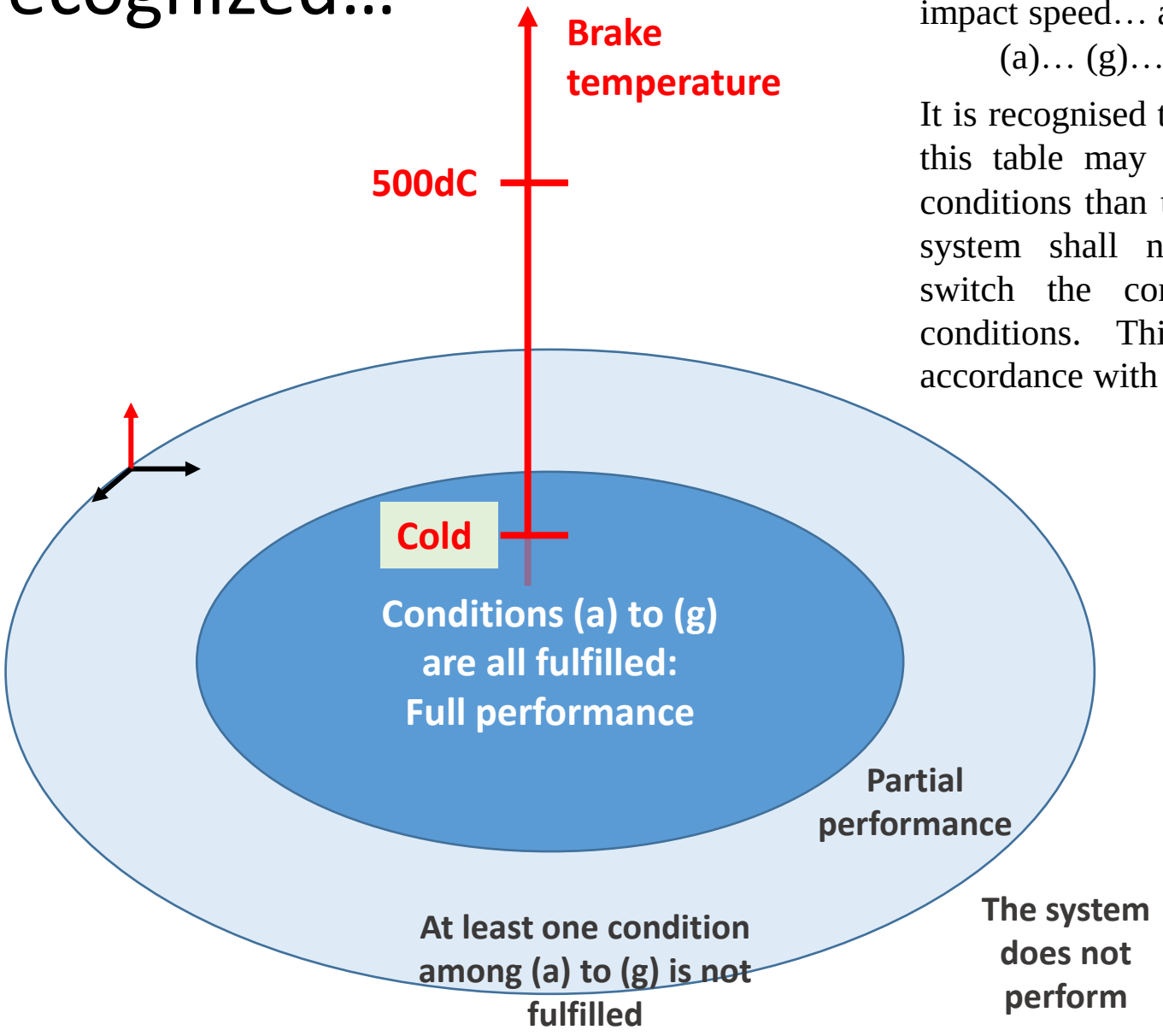
It is recognised that the performances required in this table may not be fully achieved in other conditions than those listed above. However, the system shall not deactivate or unreasonably switch the control strategy in these other conditions. This shall be demonstrated in accordance with Annex 3 of this Regulation.



“it is also recognized…”

The issue is that some conditions are not named in the list (a) to (g);

Thus, it could be interpreted that the full performance is expected whatever status these conditions have (e.g. hot brakes), provided conditions (a) to (g) are all fulfilled… which is obviously not the original intention…



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