AEB Pedestrian and Cyclist - minimum velocities

Sensor opening angles

(Theoretical) opening angles – state of the art (2017):

Source: *Shoettle, B. (2017), "Sensor fusion: A comparison of sensing capabilities of human drivers and highly automated vehicles", SWT-2017-12, University of Michigan, Transportation Research Institute, Ann Arbor.*

Radar sensors: ~15° (long range) to ~90° (short range)

(monocular) cameras: ~45° to ~90°

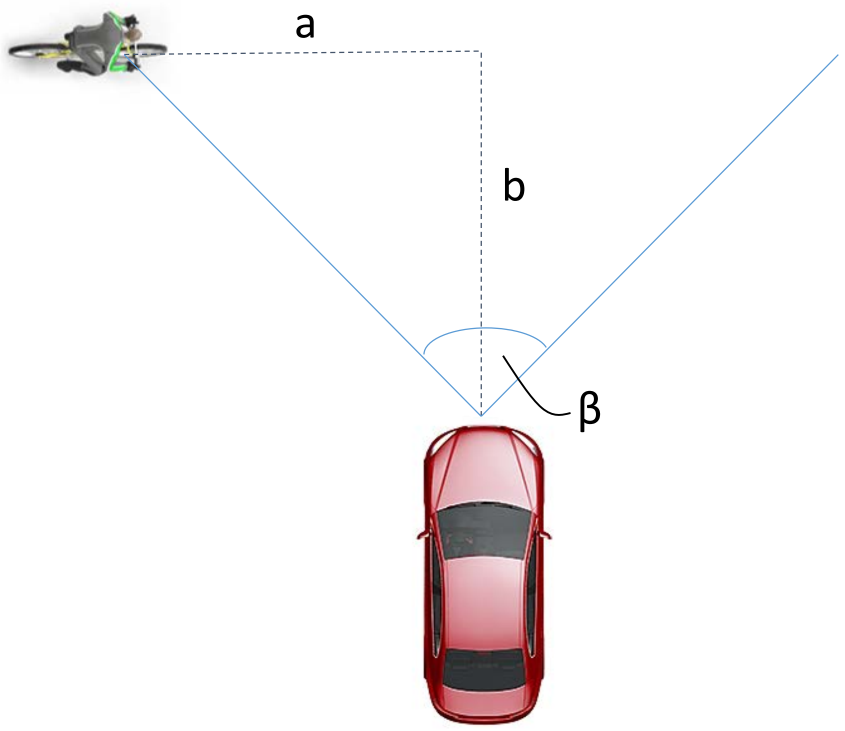
For practical applications up to ~15° must be deducted to account for

additional time for target detection and signal processing

mounting tolerances and for automatic misalignment compensation

Resulting max. opening angle of ~75°

Mathematic background - I



$$a = V_{cyclist} \cdot t_{collision}$$

$$b = V_{car} \cdot t_{collision}$$

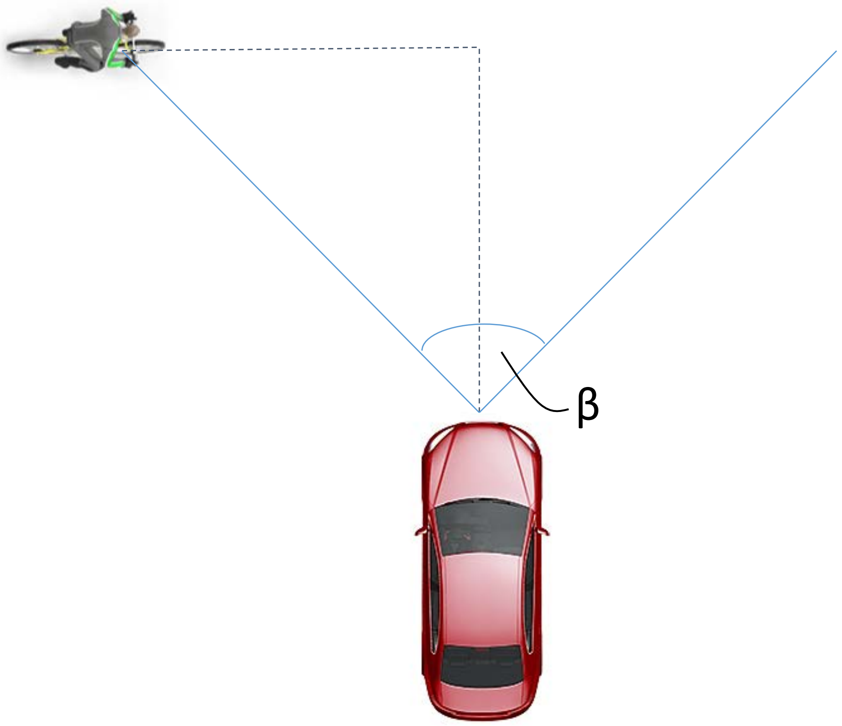
$$\tan\frac{\beta}{2} = \frac{a}{b} = \frac{V_{cyclist}}{V_{car}}$$

$$\beta = 2 \cdot \arctan\frac{V_{cyclist}}{V_{car}}$$

Impact point at 50% of front

Sensor mounted centric in front of vehicle

Mathematic background - II



Examples for required minimum opening angles:

$v_{cyclist}$ = 20 km/h
v_{car} = 20 km/h
=> β = 90°

$v_{cyclist}$ = 10 km/h
v_{car} = 20 km/h
=> β = 53°

$v_{cyclist}$ = 15 km/h
v_{car} = 20 km/h
=> β = 74°

$v_{cyclist}$ = 20 km/h
v_{car} = 10 km/h
=> β = 127°

Derived minimum velocities

Pedestrians:

Agreement reached at AEBS-05

Cyclist:

Assuming a test speed for a cyclist of **15 km/h**
=> derived minimum test speed for vehicle: **20 km/h**

Recommendation:
Minimum speed of **[20] km/h** for [both] Pedestrian and Cyclist
to account for all tolerances and in addition robustness of test conduct

NCAPs' minimum velocities (as of 2018)

Euro NCAP:

- AEB C2C 10 km/h
- AEB Pedestrian 20 km/h (Ped: 8 km/h)[1]
- AEB Cyclist 20 km/h (Cyclist: 15 km/h)[1]

China NCAP:

- AEB C2C 20 km/h
- AEB Pedestrian 20 km/h (Ped: 6,5 km/h)[1]

Japan NCAP:

- AEB C2C 10 km/h
- AEB Pedestrian 10 km/h (w/ obstruction 25 km/h) (Ped: 5 km/h)[1]

1: speeds in 50% hitpoint scenario

II. Limitations for AEB Car-to-Cyclists in crossing scenarios

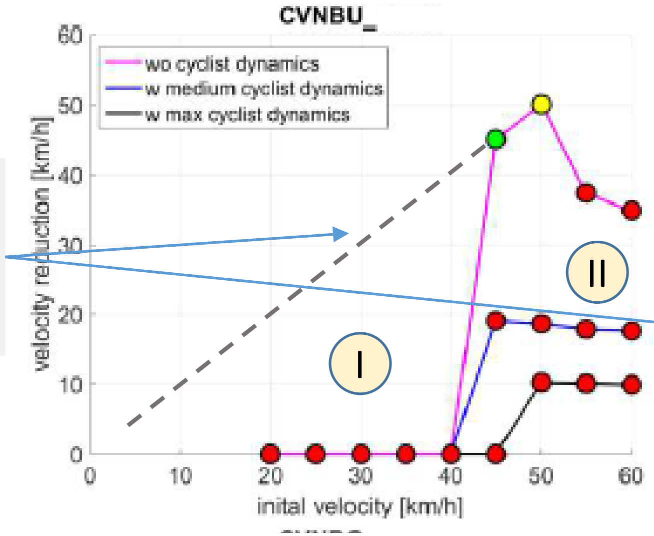
Outcome of CATS project (2 of 2)

CLEPA European Association of Automotive Suppliers

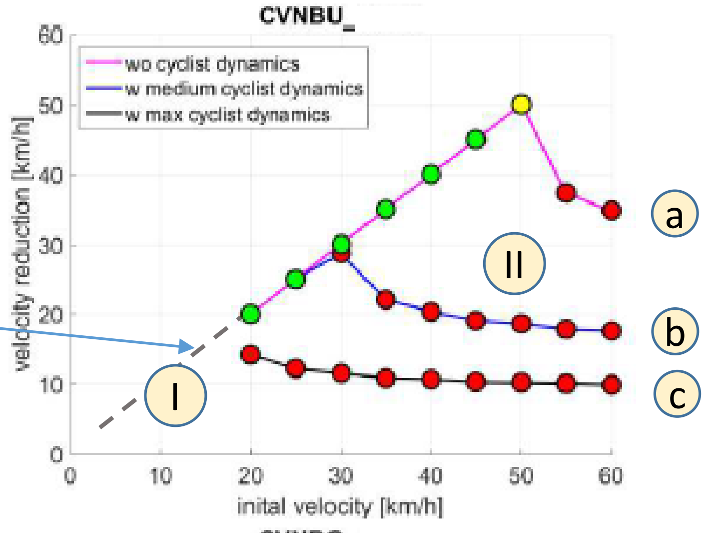
Limitation of speed reduction performance (see page 33-34 in CATS deliverable 5.1)

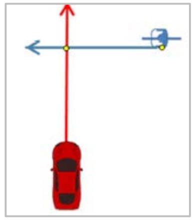
Ideal theoretical performance: Would correspond forward looking Field-Of –View up to 180°

FoV = ± 24°



FoV = ± 45°





V_{Cycl} = 15km/h

Source: CATS D5.1

I. For lower ego speed, **due to limited Field-of-View** of forward looking sensors

II. Due to potential change of cyclist movement (considering different cyclist dynamics). Braking only after “Pont of no return”, when collision is unavoidable:

a. AEB applied 1sec TTC, cyclist continues with same speed

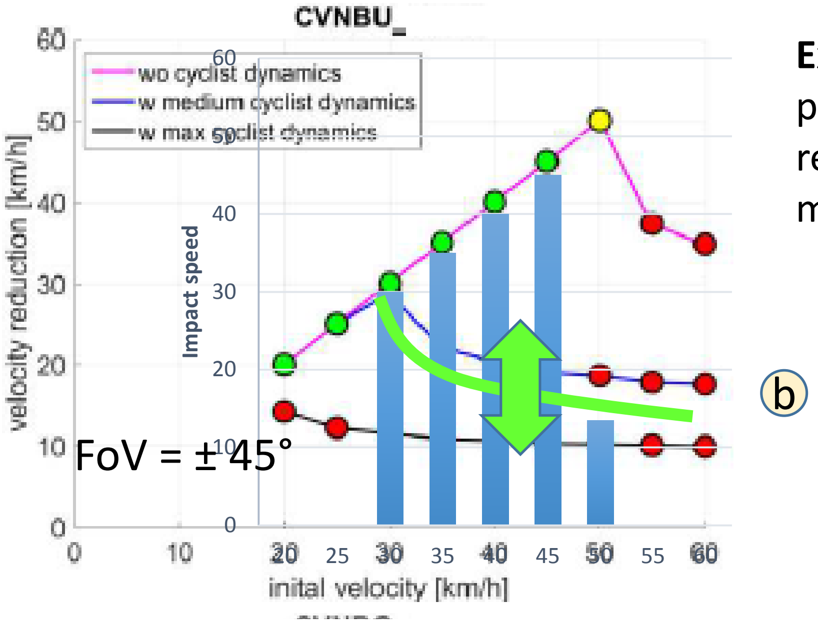
b. cyclists brakes with 4.5m/s^2,

c. Cyclists brakes with 7.0m/s^2

IV. Limitations for AEB Car-to-Cyclists in crossing scenarios

Defining legal minimum vs. Euro NCAP high performance requirements (3 of 3)

Example: 1st Euro NCAP AEB-Cyclists performance



Example: Euro NCAP performance vs. reasonable limitation for min. legal requirement

➔ **Proposal (for discussion)**: Minimum legal braking requirements for crossing cyclist should not increase the "curve of point of no return" (e.g. (b) - cyclists brakes with 4.5m/s²)