State of the Art – Parameters

Patrick Seiniger, BASt
Performance Requirements based on State of the Art

- **Challenge:** No automated vehicles exist!
- **But:** Active Safety Systems on the market
- **Possible parameters:**
  - Delay time for threat identification, brake activation
  - Brake system speed
  - Brake system deceleration
  - Steering intervention speed → No technology known, no data available to BASSt

- **Goal of this presentation:** Identify state of the art for accident avoidance
Important: Performance vs. Behavior

- Regulation should NOT specify an exact vehicle behavior
- Regulation SHOULD specify until what situations accidents should be avoided

Example for appearing pedestrian

- **Don’ts:** Behavior definition: brake at TTC=X with a deceleration of Y
- **Do’s:** Performance definition: should not lead to a collision, (because collision would be avoided if braking starts at TTC=X with a deceleration of Y)

- Other options for ADS: brake later/harder, brake earlier/softer, drive slower, drive with more lateral distance to objects.
Data from this vehicle is not used for evaluation!
Schematics – Euro NCAP Obscured Child test
Assumptions and argumentation

- In obscured child scenarios, the dummy is critical as soon as it is visible → start of braking as soon as technically possible
- Only for vehicles with Camera systems
  (RADAR might be able to see the pedestrian dummy earlier)
- Delay between appearing dummy and braking comprises
  - Detection, classification, tracking and decision making
  - Transmitting of brake command to brake system
- This is the worst case - situations with tracked objects (such as ALKS lane change) are assumed to be much faster
Delay time for threat identification

Worst case test in current NCAPs: obscured child AEB test

$$\tan \alpha = \frac{2m}{\Delta x_{\text{Camera}} + x_{\text{Veh}} - 1m} = \frac{y_{\text{Dummy,visible}}}{\Delta x_{\text{Camera}} + x_{\text{Veh}}}$$

$$y_{\text{Dummy,visible}}(x) = \frac{2m \cdot (\Delta x_{\text{Camera}} + x_{\text{Veh}})}{\Delta x_{\text{Camera}} + x_{\text{Veh}} - 1m}$$

$y_{\text{Visible}} = \alpha(x) \leq \alpha_{\text{Camera}} \lor y_{\text{Dummy}} \geq y_{\text{Dummy,visible}}$
Brake system speed & deceleration

- $a_{\text{max}} = d_{\text{max}}$

- **Brake system deceleration**
  - $d_{\text{max}}$

- **Brake system speed**
  - $t_{0-1g} = t_{0-decel,max} \cdot \frac{9.81 \text{m/s}^2}{d_{\text{max}}}$
Small SUV

Brake deceleration over time

Reaction delay
Max. Deceleration
Time-To-1g

~M:0.63
~M:11
~M:0.46
Large SUV

Brake deceleration over time

Reaction delay
Max. Deceleration
Time-To-1g

~M:0.62
~M:11
~M:0.72
State of the Art – Possible parameters

These parameters show what is currently possible

They should provide a reference for the expected performance in accident-prone situations (see slide 3)

Reference: Performance, not behavior, should be required (slide 3)

Reaction delay (object appearance → start of braking / swerving): Not more than 0.57 seconds

Brake speed (time to reach 1 g): Not more than 0.5 to 0.66 s (depending on vehicle mass)

Maximum brake deceleration: not less than available μ!

Steering performance – no systems available yet