Motivation of Cut-In Requirements

Additional explanation to paragraph 5.2.5.2. of the draft UN Regulation for ALKS (GRVA-05-07)
Cut-In Requirements: Model for ADS Behavior

No intervention required

Intervention assumed for original proposal

Intervention assumed for new proposal

ALKS Vehicle → Intruding Vehicle

ALKS Vehicle → Intruding Vehicle

ALKS Vehicle → Intruding Vehicle

30 cm
Cut-In Requirements: Intervention Concept

Monitor other traffic (continuously)

Decide Brake Intervention (instantaneously)

Transmission delay

Increase brake force

Full braking phase

1st Parameter: Ass. decision strategy

3rd Parameter: typical jerk

2nd Parameter: typical delay

4th Parameter: available deceleration

Unpreventable: Avoidance not required. Do not switch strategy!

Decision too late
$\text{TTC} < \text{TTC}_{\text{min}}$

Decision in time
$\text{TTC} \geq \text{TTC}_{\text{min}}$

Preventable: Avoidance required
Cut-In Requirements: Intervention Model

Start of Intervention

ALKS Vehicle

Intruding Vehicle

30 cm

ALKS decides intervention: other traffic enters lane by > 30 cm

ALKS monitors other traffic

deceleration relative speed
Cut-In Requirements: Intervention Model (2)

Start of Intervention

ALKS Vehicle

Intruding Vehicle

ALKS decides intervention: other traffic enters lane by > 30 cm

ALKS monitors other traffic

Decision in time
TTC ≥ TTC_{min}

deceleration
relative speed (avoidance case)

30 cm

t_{delay}

t_{increase, deceleration}

decel_{max}

0
Cut-In Requirements: Intervention Model (3)

Start of Intervention

ALKS Vehicle

Intruding Vehicle

ALKS monitors other traffic

ALKS decides intervention: other traffic enters lane by > 30 cm

deceleration

relative speed (mitigation case)

Decision too late
TTC<TTC_{min}

delay

increase,
deceleration

delel_{max}

0
Mathematical Model for Edge TTC

- TTC for brake start to avoid collision with deceleration $d$:

$$TTC_{\text{avoidance}} = \frac{v_{\text{rel}}}{2 \cdot d} = \frac{v_{\text{rel}}}{2 \cdot |\ddot{x}_{\text{max}}|}$$

- Approximation (avoiding numeric integration) for jerk influence:

$$TTC_{\text{avoidance}} = \frac{v_{\text{rel}}}{2 \cdot |\ddot{x}_{\text{max}}|} + \frac{1}{2} t_{\text{increase}}$$

$$t_{\text{increase}} = \frac{\ddot{x}_{\text{max}}}{\ddot{x}_{\text{available}}}$$

- Take "dead time" delay (command transmission etc) into account:

$$TTC_{\text{avoidance}} = \frac{v_{\text{rel}}}{2 \cdot |\ddot{x}_{\text{max}}|} + \frac{1}{2} t_{\text{increase}} + t_{\text{delay}}$$
Parameter Derivation

1st Parameter: Ass. decision strategy

Assume an intrusion of 30 cm into lane can be considered critical (intrusion continuously monitored!)

2nd Parameter: typical delay

Transmission in bus system, overcome actuator friction, ...

100 ms (confirmed by manuf.)

3rd Parameter: typical jerk

Typical (own measurement): 0.4 – 0.6 s from 0 to 10 m/s²
New brake systems (own measurement): 0.15 s from 0 to 10 m/s²
Assumed (conservative!) in DE/FR prop.: 0.5 s from 0 to 6 m/s²

4th Parameter: available deceleration

Typical value from field data: 6 m/s² available also on wet roads.

\[ \frac{v_{rel}}{2 \cdot |\ddot{x}_{max}|} + \frac{1}{2} t_{\text{increase}} + t_{\text{delay}} \]

\[ \frac{v_{rel}}{2 \cdot 6 \text{ m/s}^2} + \frac{1}{2} 0.5s + 0.1s = \frac{v_{rel}}{2 \cdot 6 \text{ m/s}^2} + 0.35s \]
3rd Parameter: typical jerk

0.48 s from 0 to 9.9 m/s²
4th Parameter: available deceleration
Summary

- DE/FR model assumes a continuous monitoring of traffic in adjacent lanes
- DE/FR model assumes a critical condition and consequently a brake intervention when other traffic enters > 30 cm into ego lane
- DE/FR model assumes a plausible delay (transmission, actuator friction) of 0.1 s
- DE/FR model assumes a brake intervention with 6 m/s² reached in 0.5 seconds
- These values have been shown to be realistic
- DE/FR position: Automated vehicles should not be required to have a weaker performance than current ADAS-equipped vehicles
Comparison of JP and DE/FR DTC values

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<td>v_{rel} [km/h]</td>
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