



Federal Ministry  
of Transport and  
Digital Infrastructure

Informal Document ACSF-02-10

# Identification of regulatory needs for ACSF

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## Basics

Prerequisites for the following considerations are that

- in principle the driver is obliged to surveil the ACSF continuously and must be able to take over manual control at any time
- driving with ACSF shall be at least as safe as steering manually



## Basics

- ACSF means continuous lateral control by automatic steering
- Automatic lateral control is needed for:
  - following the path of a vehicle in front of the EGO-vehicle
  - keeping the vehicle in a lane with orientation by means of road markings
  - lane changing manoeuvres



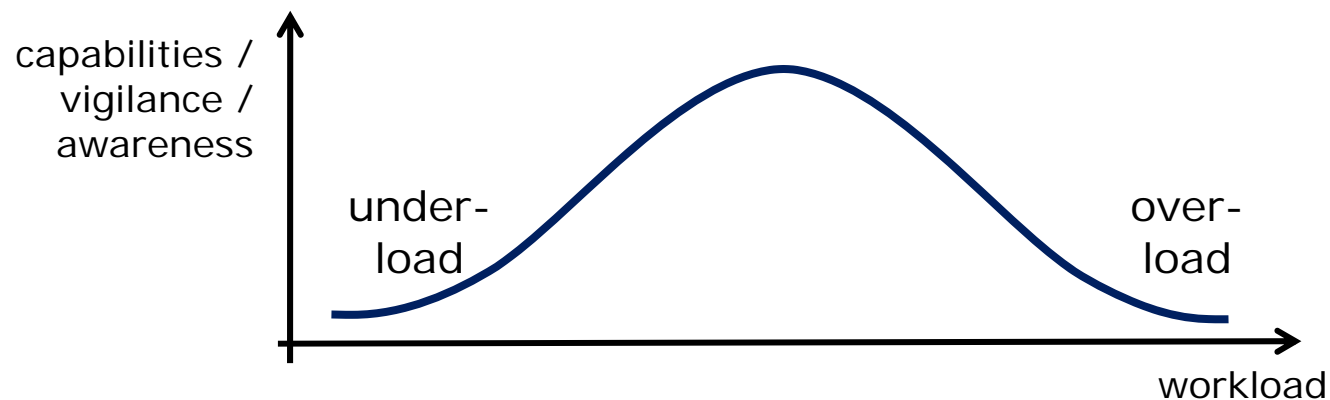
## Basics

- The task is to derive general regulatory needs and performance requirements for ACSF
- Performance requirements have to cover:
  - a) „Normal“ driving with ACSF (carrying out the manouvres that ACSF was designed for)
  - b) The transition from manual steering to driving with ACSF and (even more important) the transition back to the driver when ACFS's system functionality boundary will be reached
  - c) Driver is or is going to be inattentive
  - d) Unexpected and critical events during driving with ACSF



## HMI - Human capabilities to surveil

Establishing requirements we have to take into account:



- The capabilities of a human being degrade if workload is too high or too low
- The human being is not good in only surveilling a system
- Well working ACSF (possibly used together with ACC) may encourage the driver to do other tasks than controlling the vehicle or surveilling the ACSF

*Sources: see paper "HMI concept of ACSF - background knowledge from research"*



## HMI - Interaction between ACSF and driver

Design of ACSF has an influence on the driving task and thus on the capabilities of the driver (on vigilance, situation awareness, reaction times...)

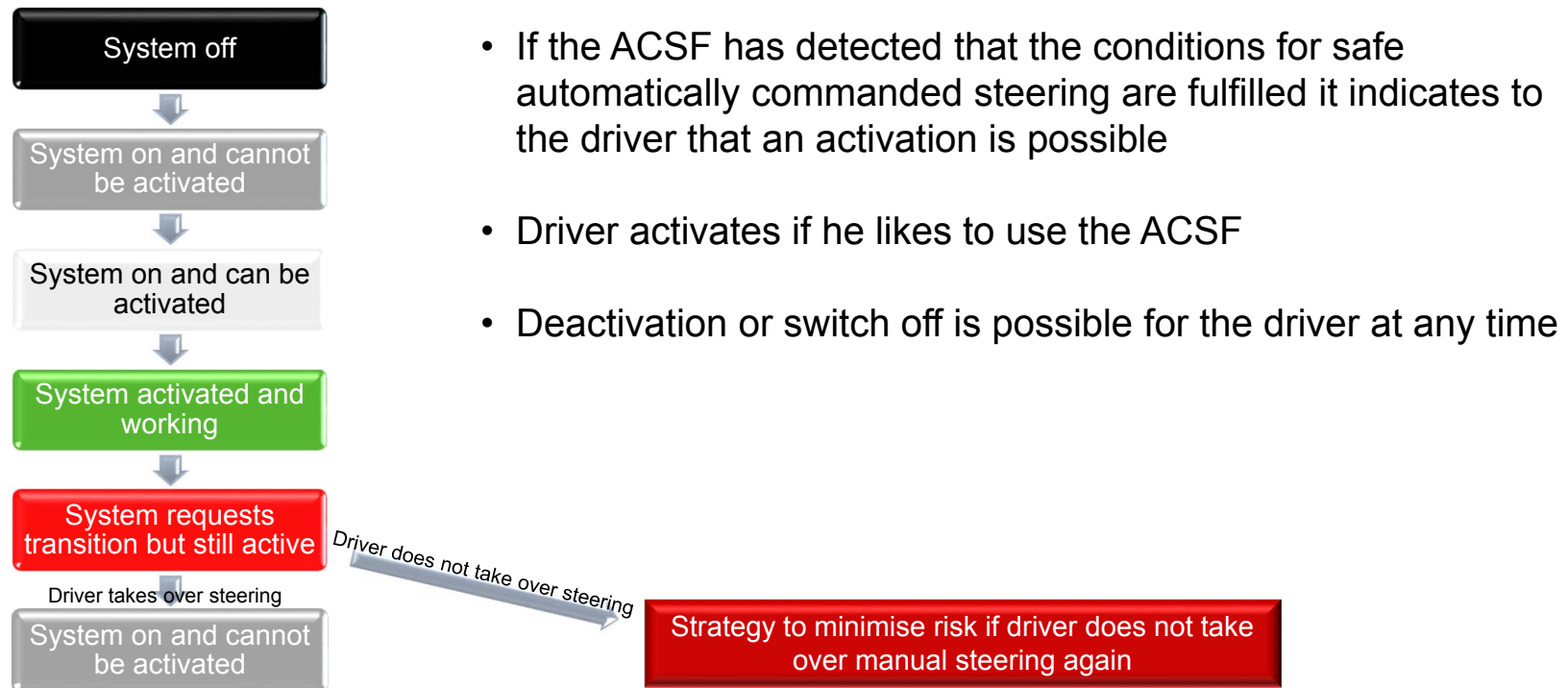


Capabilities of the driver have to be taken into account when designing an ACSF and when establishing requirements for ACSF (ensuring mode awareness, signalling of system boundaries, design of warnings,...)



## HMI - Indication of ACSF system status

**Needed:** Clear and unambiguous (redundant) signalisation to the driver in which status the ACSF is in order to achieve mode awareness at





## HMI - Reaction times of the driver Basics

driver status	Reaction time <sup>1</sup>
Full situation awareness	About 0.7 s to 1.4 s
Manual driving but distracted	About 1 s to 2 s
Only monitoring	About 5 s (study, simulator)
Other task than driving becomes primary task	Can be much longer <sup>2, 3</sup>

<sup>1</sup>Sources:

- see AEBS/LDW-06-08
- see AEBS/LDW-07-05
- further sources in paper "HMI concept of ACSF - background knowledge"

<sup>2</sup>depends considerably on traffic situation, time since automated function started, driver capabilities, driver age,...

<sup>3</sup>research to determine human reaction while driving with automated driving tasks has just started!





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# General Requirements



## a) Normal driving with activated ACSF

General objectives:

- Safe path following
- Safe lane keeping
- Safe lane change
  - ACSF should not cause safety critical situations
  - Steering manoeuvres must be clear to other road users

Needed:

- Limit lateral acceleration to [3] m/s<sup>2</sup> in order to avoid high dynamic manoeuvres
- Minimum distance (e. g. in terms of minimum time gap) to other road users in all driving situations at any time (not only laterally but also longitudinally, Interaction with the brake seems necessary)
- direction indicators must be activated automatically in case of ACSF lane change manoeuvres



## b) Transition from ACSF to manual steering

Reaching the ACSF system boundaries will result in a transfer of the steering task back to the driver e. g. in the situations (depending on ACSF system functionality)

- Specified speed boundaries are reached
- End of congestion / lead vehicle gone
- Sensor's capabilities reduced (e.g. snow)
- Construction site / lane too narrow / end of lane
- Road marking with degraded quality
- Road curvature too tight
- ...



It must be ensured that safe transition to manual steering is possible at any time → Needed: If system will not be able to cope with oncoming circumstances:

- Early request to the driver that that transition from ACSF to manual steering is necessary and that the driver must take over control of the steering task
- Request using at least 2 sensory channels, escalating warning



## b) Transition from ACSF to manual steering

If the driver does not take over the steering after a transition request was given by the system

- ACSF must comprise some strategy to reach a status with as less risk as possible in the given traffic situation

Needed e. g.:

- Further lane keeping for a certain time
- Enlarging gap to other road users
- Slowing down to standstill
- Switching hazard lights on
- If lane change is part of ACSF's system functionality: lane change to edge of the road
- ...
- (or a combination of the above mentioned actions)



## c) Driver is going to be inattentive

- ACSF shall ensure the drivers attentiveness
  - Means to detect drivers attentiveness  
(e.g. Driver absence detection, Hands off detection, Torque sensing)
  - Means to maintain or regain situation awareness
  - If inattentiveness remains: start transition procedure
- ACSF shall have minimum precautionary measures to avoid to misuse
  - Warning and Transition request if driver seatbelt is unfastened
  - Warning and Transition request if driver seat is left



## d) Unexpected critical events

The ACSF shall be able to cope with unexpected and sudden critical events (time is too short for safe transition procedure)

e. g. in the cases:

- Obstacle in lane
- Accident is happening just ahead
- Pedestrian steps on the road
- Emergency braking of the vehicle in front
- Cutting-in vehicle is going to cause side collision
- Lane change manoeuvre of EGO-vehicle coincident with lane change of another vehicle targeting the same lane at the same position

Needed:

- Automatic emergency braking
- Abortion of manoeuvres (e. g. in lane change)
- Evasive steering (on manufacturer's choice)



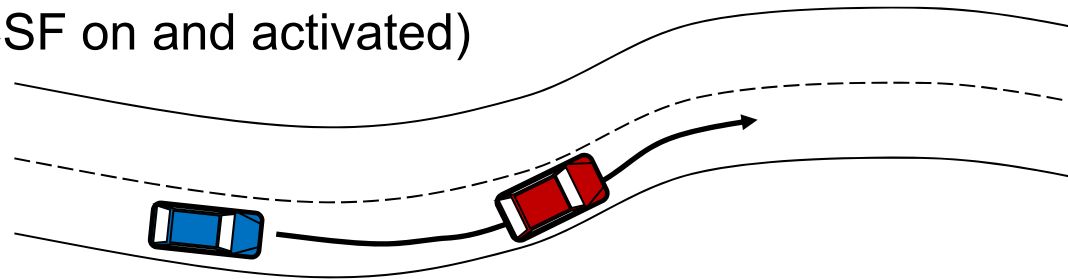
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# Possible Tests



## Test of functionality (advanced lane keeping)

Check if vehicle stays on path under normal operating conditions (ACSF on and activated)



### Test FU1

- at least 5 min driving behind a lead vehicle (ACSF on and activated) (time gap: 2 s to 3 s for manual speed adjustment, otherwise time gap is selected by the vehicle itself)
- lead vehicle shall drive within the lane markings with  $a_y \leq 1 \text{ m/s}^2$
- on a track with road markings of good visibility at each side of the lane
- at various speeds up to  $v_{\text{max}}$  and down to  $v_{\text{min}}$
- with various curvatures

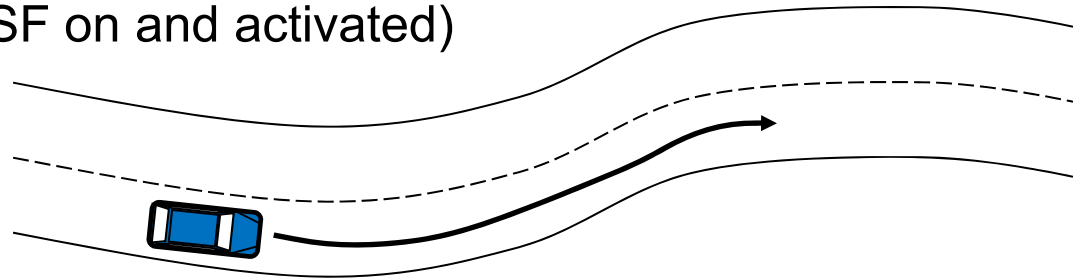
Test is passed: vehicle does not cross any lane marking





## Proposal - Test of functionality (advanced lane keeping)

Check if vehicle stays on path under normal operating conditions (ACSF on and activated)



### Test FU2

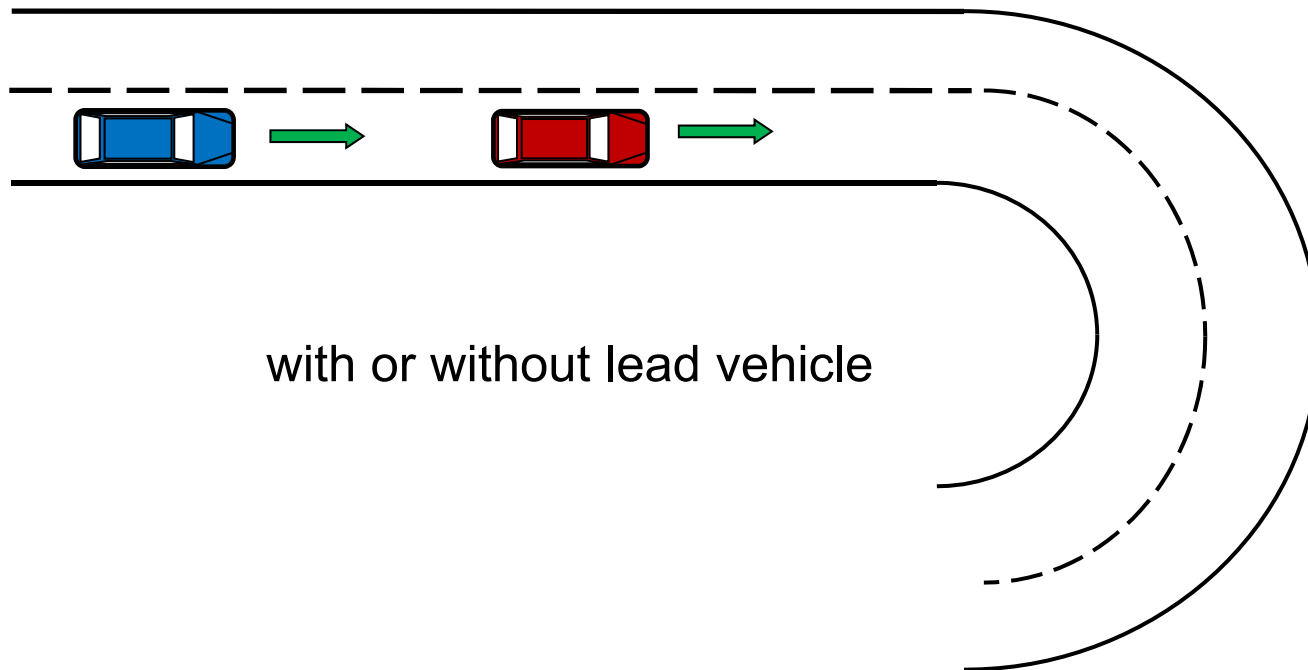
- at least 5 min driving without a lead vehicle (ACSF on and activated)
- with  $a_y \leq 1 \text{ m/s}^2$
- on a track with road markings of good visibility at each side of the lane
- at various speeds up to  $v_{\text{max}}$
- with various curvatures

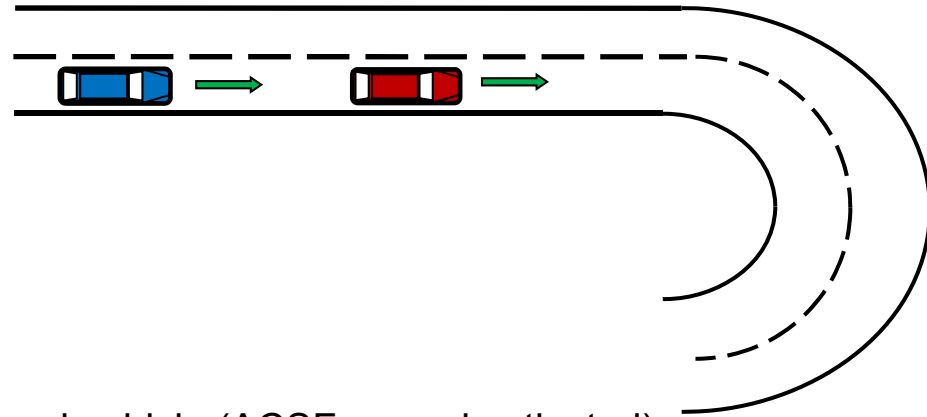
Test is passed: vehicle does not cross any lane marking



## Test of transition request at system boundaries and minimum risk manoeuvre

tight curve:  $a_y$  beyond system boundaries



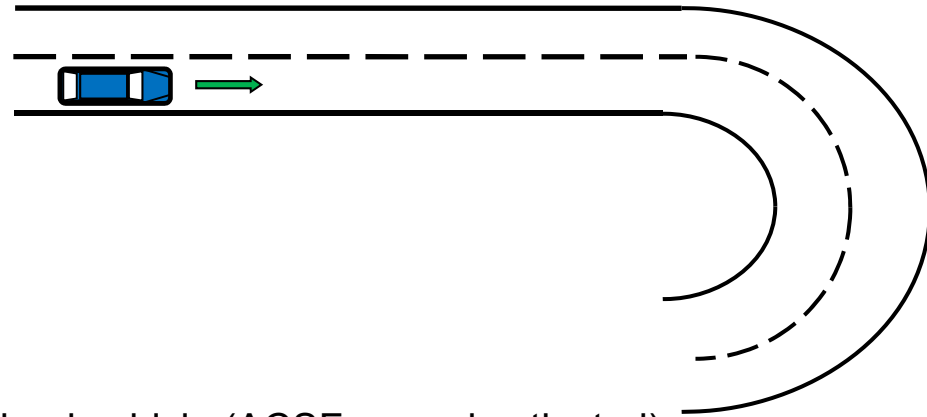


## Test TR1

- driving at least 1 min behind a lead vehicle (ACSF on and activated)
- lead vehicle shall drive within the lane markings
- on a track with road markings of good visibility at each side of the lane
- at a speed of 10 km/h below  $v_{smax}$
- after a straight section of at least 200 m the vehicle shall approach a curve of more than  $90^\circ$  that would demand an  $a_y$  of more than  $[3] \text{ m/s}^2$
- test driver shall not take over manual steering control again

## Test is passed:

- transition request was given at least when the lateral acceleration exceeds  $[3] \text{ m/s}^2$
- the minimum risk maneuver as specified by the manufacturer was initiated
- vehicle does not cross any lane marking before the minimum risk manoeuvre was initiated.



## Test TR2

- driving at least 1 min without a lead vehicle (ACSF on and activated)
- on a track with road markings of good visibility at each side of the lane
- at a speed of 10 km/h below  $v_{smax}$
- after a straight section of at least 200 m the vehicle shall approach a curve of more than 90° that would demand an  $a_y$  of more than 3 m/s<sup>2</sup>
- test driver shall not take over manual steering control again

### Test is passed:

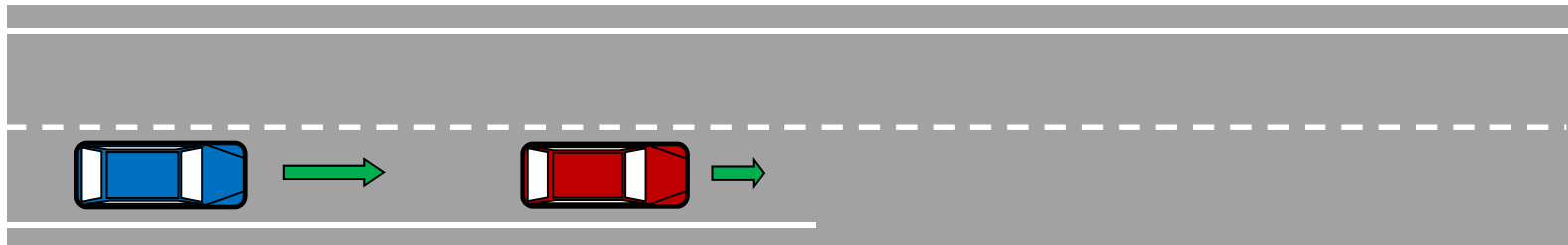
- transition request was given at least when the lateral acceleration exceeds [3] m/s<sup>2</sup>
- the minimum risk maneuver as specified by the manufacturer was initiated
- vehicle does not cross any lane marking before the minimum risk manoeuvre was initiated.



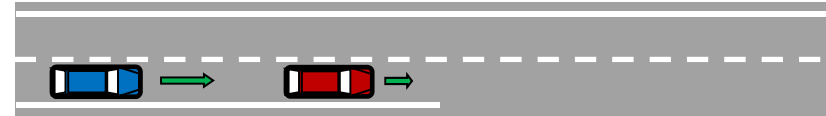
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## Test of transition request at system boundaries and minimum risk manoeuvre

lane markings quality beyond system boundaries



with or without lead vehicle



## Test TR3

- driving at least 1 min behind a lead vehicle (ACSF on and activated)
- lead vehicle shall drive within the lane markings
- on a track with road markings of good visibility at each side of the lane
- at a speed of 10 km/h below  $v_{\text{max}}$
- after a straight section of at least 200 m the vehicle shall approach a section with a length of 200 m with only one lane marking at the driver's side
- test driver shall not take over manual steering control again

### Test is passed:

- vehicle does not cross any lane marking and
- the transition request was given [0 s] before the vehicle would have entered the section with missing lane marking and
- the minimum risk maneuver as specified by the manufacturer was initiated



## Test TR4

- driving at least 1 min without a lead vehicle (ACSF on and activated)
- on a track with road markings of good visibility at each side of the lane
- at a speed of 10 km/h below  $v_{smax}$
- after a straight section of at least 200 m the vehicle shall approach a section with a length of 200 m with only one marking on the driver's side
- test driver shall not take over manual steering control again

## Test is passed:

- vehicle does not cross any lane marking and
- the transition request was given [5 s] before the vehicle would have entered the section with missing lane marking and
- the minimum risk manoeuvre as specified by the manufacturer was initiated

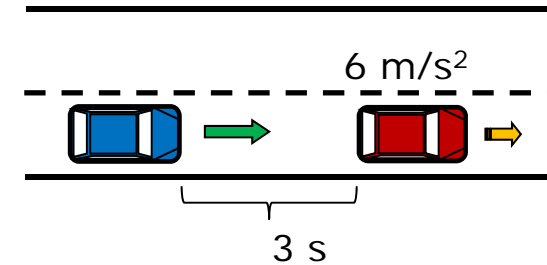


## Emergency Tests

### Test Em1

Basic automatic emergency braking capability if lead vehicle suddenly decelerates sharply (ACSF on and activated)

- Test speed of both vehicles 10 km/h below  $v_{\text{smax}}$
- Initial time gap 3 s
- Lead vehicle deceleration  $6 \text{ m/s}^2$ , mean jerk  $6 \text{ m/s}^3$



Test is passed: No collision







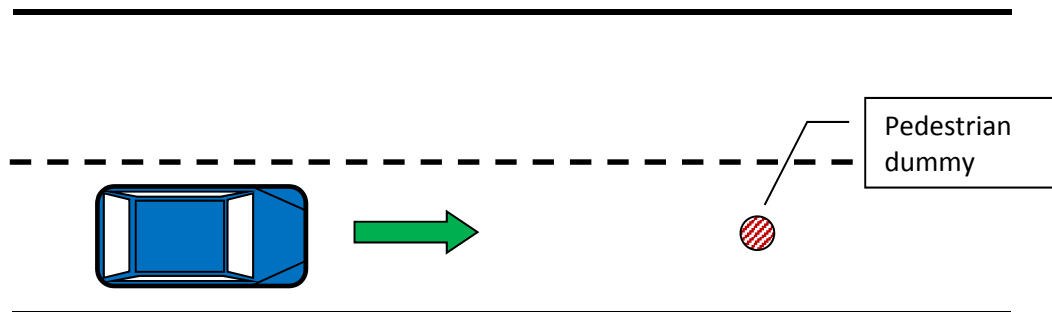
## Emergency Tests

### Test EM2

Basic automatic emergency braking capability if pedestrian stands statically in the lane (ACSF on and activated)

- Test speed 10 km/h below  $v_{\text{max}}$
- Pedestrian centered in the lane

Test is passed: No collision

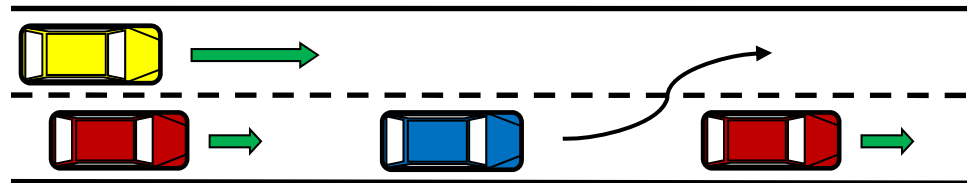




## Emergency Tests

### Test EM3

Abortion capability if second lane is suddenly occupied by another vehicle  
(ACSF on and activated)



- ego vehicle drives between two other vehicles in same lane, all at [30 km/h] below  $v_{smax}$  or at  $v_{smin}$ , whatever is higher (perhaps test at lower speeds for safe testing necessary)
- time gap to two other vehicles 3 s
- during lane change third vehicle overtakes with 50 km/h above  $v_{smax}$
- TTC of third vehicle at point in time when vehicle under test is crossing lane: [2 s]

Test is passed: Abortion of overtaking manoeuvre and lane keeping continues

Thank you for your attention!

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